POWER PLANT ENGINEERING

Established Over 29 Years

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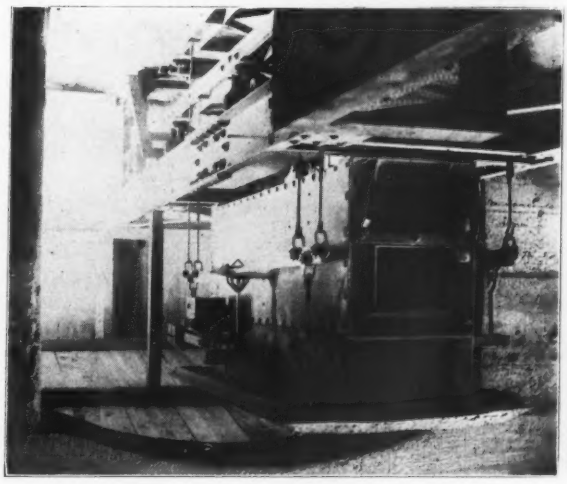
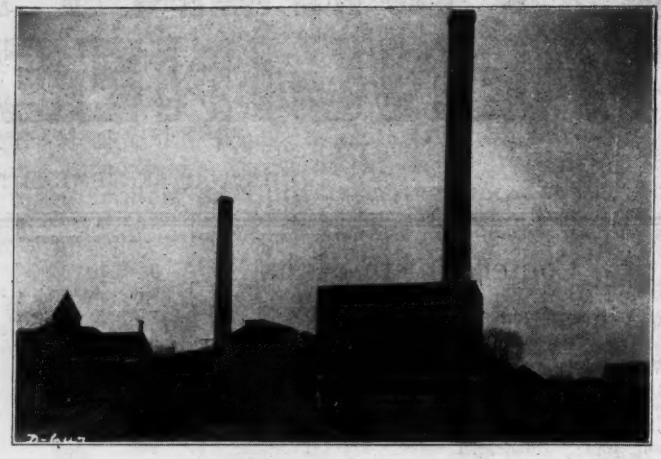


One Watt=One Pound

YOU HAVE often heard the statement that "a pint's a pound the world around," or "2.304 ft. equals one pound." Of course, neither of these statements means exactly what it says. What it does mean is that a definite relation exists between the two systems of units and that the amount can be translated from one kind of unit to another. That is just what is accomplished by the device shown in the above picture: it translates watts into pounds.

This device is a conveyor scale for weighing coal, ash, or other materials as they pass over some form of continuous conveyor. The conveyor chain or belt is supported on the scale arms in such a way that the tare, or weight of the conveyor itself, is automatically balanced and does not enter into the reading. As the conveyor passes over the scale, it drives an electric generator. The product of the current and voltage of this generator are measured by a wattmeter and, by an ingenious arrangement of dashpots, the wattmeter reading is made to represent the weight in pounds of the material being conveyed. In other words, for every watt recorded by the meter, one pound of material passes the scale. On page 884 of this issue, this scale is described more fully, especially as it applies to ash conveyors. Other interesting types of ash-handling equipment are also discussed in this article.



Purdue University Builds New Plant

NEW POWER PLANT FOR UNIVERSITY AT LAFAYETTE IS BOTH A POWER PRODUCING PLANT AND AN ENGINEERING LABORATORY

IN THE TRAINING of engineering students at a large university one of the most important assets such an institution can possess is a suitable power plant. The power plant of an engineering college is more than a means for producing power and heat; it is a laboratory where the students are taught the design, operation and testing of heating and power-station equipment.

Knowing this fact and realizing the inadequacy of their old power plant, the Board of Trustees of Purdue University at Lafayette, Indiana, requested the Legislature of 1923 to appropriate money for the construction of a new power and heating plant which would not only fulfill the heating and power requirements imposed by the steady growth in the size of the University but which would also be one of the most complete and modern of its size in the country.

Acting on this request, the Legislature appropriated $275,000 to start the construction of the plant which is described in this article.

The old power plant which served the University until the present plant was built and is, in fact, still used as a standby, was built in 1903, the original installation consisting of four 250-hp. boilers and one 75-kv.a. engine-driven generator. To meet the growth of the University, one boiler was added in 1909 and the generating equipment was increased by the purchase of a new 225-kv.a. engine-driven generator. In 1912, another boiler was installed, thus completing the building program for the plant.

Since that time, however, the University has grown considerably and many new buildings have been erected. Purdue University ranks now as the second largest engineering college in this country. To meet the increase in load imposed by this expansion, the power producing equipment has been forced to capacites far beyond those for which they were originally designed, resulting in uneconomical operation. Expansion is still proceeding and, with the building program planned during the next few years, an increase in the heating load over the present load of about 60 per cent is expected.

The electric generating capacity of the old plant has also proved inadequate and for some time the University has been purchasing electrical energy from the local utility company. In 1922, about 30 per cent of the electricity consumed was purchased. The need for a new plant of adequate capacity was apparent.

CONSIDERATIONS INVOLVED IN THE DESIGN OF THE NEW PLANT

Before designing the new plant a careful study was made of the probable future requirements, both as to the heating and electrical loads. This study showed that at that time 4000 b.hp. were required for heating purposes and that the maximum quarter hour demand for electrical energy was 600 kw. with a peak demand of 900 kw. Analysis also indicated that both the heating and electrical loads would be doubled within the next ten years.

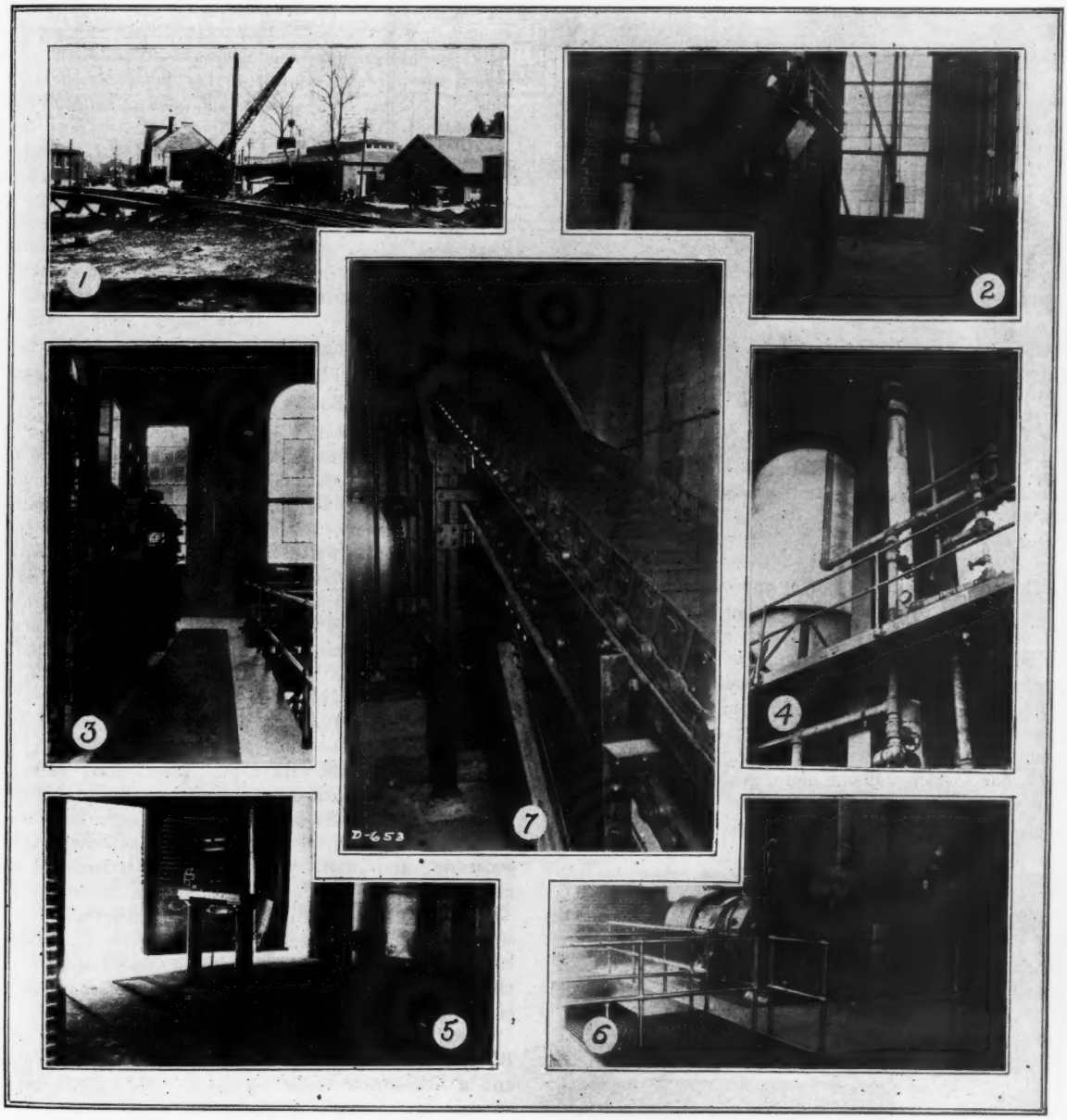
A plant designed for an ultimate capacity of 4000 boiler horsepower with boilers capable of being operated at 200 to 250 per cent rating and with generator capacity totaling 1300 kw. was decided upon. A complete waterworks service and fire system were to be included at some future date if the West Lafayette Water Works Co. finds it difficult to handle the University load at reasonable cost.

In considering the location of the new plant, it was deemed highly desirable that it be placed centrally with respect to the buildings to which heat is supplied, and

at the same time, from the standpoint of laboratory requirements, be located centrally with respect to the engineering buildings; furthermore, that it should be located where there would be sufficient room to store an adequate supply of coal in an inconspicuous place. To satisfy these requirements a site was selected directly north of the old power plant.

General Arrangement of the Ultimate Plant

The initial installation which has just been placed in operation represents only a part of the proposed layout; in fact, it is very much less than half of the ultimate. In order, however, to give the reader an idea of the plant as it will be when entirely completed, we will describe briefly the main features of the ultimate plant. The general arrangement is shown in Fig. 11. The boiler room will be 165 ft. long by 52 ft. wide and will contain 8 500-hp. boilers arranged in four batteries of two boilers each. These units will be located in a single room with the stack in the center, as shown. The firing floor on which these boilers are placed is 14 ft. above the ground floor, giving a well-lighted and ventilated basement in which are to be located the boiler feed pumps, chemical mixing tank, forced draft fans, ash handling equipment, surge tank and service pumps. A 350-T. coal bunker, 70 ft. long, is located above the firing aisle in the south half of the boiler



FIGS. 1-7. GENERAL VIEWS OF THE NEW POWER PLANT AT PURDUE

Fig. 1. The 1st locomotive crane in action. Fig. 2. A view of the firing aisle. Fig. 3. The switchboard. Fig. 4. The sedimentation tank of the water treating system is placed on a platform 13 ft. above the firing floor. Fig. 5. A platform scale is provided for weighing the ash cars before being emptied. Fig. 6. A view of the 500-kw. turbo-generator. Fig. 7. The apron conveyor delivering coal from the crusher to the bucket elevator.

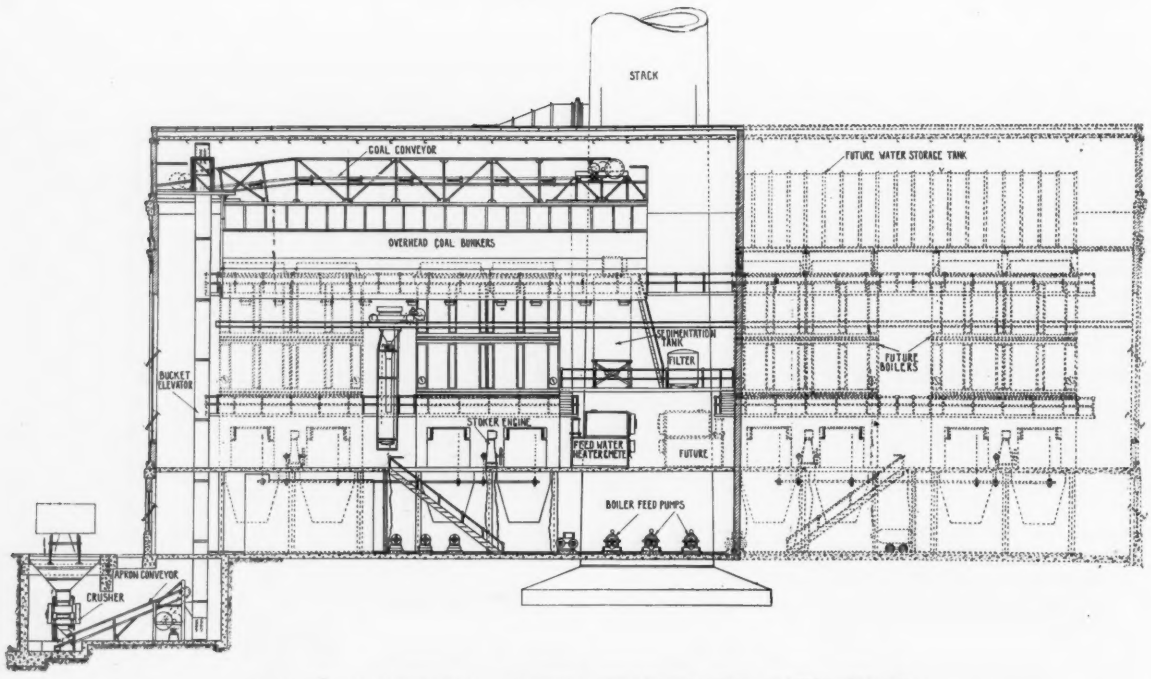


FIG. 8. LONGITUDINAL SECTION THROUGH THE BOILER HOUSE

room. A 75,000-gal. water tank to store water will occupy the space above the firing aisle in the north half of the boiler room.

The ultimate generator room will be 120 ft. in length by 38 ft. wide and will contain one 300-kw. engine-driven unit, two 500-kw. turbo-generators and two 150-kw. motor generator sets, together with the necessary auxiliary apparatus.

The Present Installation

The present plant consists of approximately one-fourth of the ultimate equipment installation and only the south half of the building. This contains at the present time, two boilers, part of the coal bunker, the stack, the complete water softening equipment, one feed water heater, feed pumps, one forced draft fan and coal and ash handling machinery. The turbine room contains one turbo-generator complete with condensing equipment, the switchboard, one exciter and one motor-generator set. There is space in this half of the building, however, for two more boilers, another forced draft fan, one feed water heater, and the 300-kw. engine-driven generator referred to in the foregoing description of the ultimate layout.

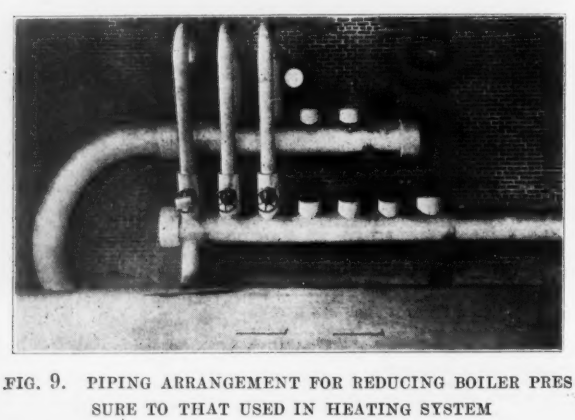


FIG. 9. PIPING ARRANGEMENT FOR REDUCING BOILER PRESSURE TO THAT USED IN HEATING SYSTEM

Boiler Equipment

The boilers installed are rated at 500 hp. and are Stirling Class XIII units with 5005 sq. ft. of heating surface operating at about 200 per cent rating and at a pressure of from 195 to 200 lb. These units are set in battery but with independent settings, having a two-inch air space between the inside walls. Each boiler is equipped with a four retort, 25 tuyere, Taylor Underfeed Stoker having an active grate area of 82.6 sq. ft. and a ratio of heating surface to grate area of 60.5. Since the boiler equipment is designed for burning low grades of Indiana coal at 200 per cent continuous rating, the boilers are set with the mud drums 12 ft. above the floor. This gives a combustion chamber of 2110 cu. ft. per boiler, or a ratio of heating surface to combustion space of 1 to 0.422. The settings are constructed with Liptak interlocking walls and with fire brick furnished by A. P. Green Firebrick Co.

One of the boilers is fitted with a Foster superheater designed to furnish steam at 100 deg. superheat to the generating and auxiliary units. The other boiler is used mainly to supply saturated steam to the heating system. The plant is so designed that upon the installation of the second battery of boilers, the second boiler of the present battery will be equipped with a superheater to furnish additional superheated steam to the Mechanical Engineering Laboratories.

Each boiler is fitted with 6 Vulcan Soot Blower units, Bailey Multi-pointer draft gages, Bailey Boiler Feeder, and a Copes feed water regulator. The Carrick system of combustion control is used.

The stokers are driven through a line shaft by a 6- by 7-in. Troy vertical steam engine. This engine is also controlled by the Carrick System.

Air for combustion is supplied to the furnaces by one Green Radial Flow fan, rated at 60,000 cu. ft. per

min., large enough to supply four boilers at 200 per cent rating. This fan is direct connected to a 120-hp. Terry steam turbine. Three additional fans will be required in the complete power plant. These fans, as is the case with the one now installed, will be located on the ground floor and will discharge into concrete air ducts placed below the basement floor as shown in the cross section of the plant in Fig. 12. These ducts are of rectangular cross section and extend the entire length of the power plant. Vertical risers fitted with control dampers extend from these main ducts to the stokers above. These dampers are under the control of the Carrick System. The reason for using this type of duct design was not only to secure neatness and for the ease with which calibration tests may be made by students, but also because at some future date it might be desirable to install powdered coal furnaces under some or all of the boilers. If this is done it will merely be necessary to cut suitable openings in the fire room floor and extend the furnace walls down to the basement floor. No ducts will be in the way and therefore the changes may be effected with a minimum of expense.

With regard to the installation of the additional boilers, all openings in the boiler room floor for the proposed units have been made and in the basement the openings to the forced draft ducts are also provided. These are at present provided with wooden covers.

The forced draft fans are located in a separate room fitted with steel curtain doors.

Coal Handling

The coal handling equipment is designed to handle run-of-mine coal as received in railroad cars at grade level, crush it to stoker size and deliver it to the overhead bunker in the boiler house, and thence to feed it by means of a motor propelled weighing larry to the stokers.

Coal is delivered by railroad cars and discharged either into a storage pit or into a double track hopper next to the boiler house for immediate delivery to the plant. The storage pit is located just east of the plant and will be a concrete pit with 8000-T. capacity. The coal is stored at a maximum depth of 10 ft. to eliminate danger from spontaneous combustion. A standard gage steel trestle supported on concrete piers is located through the center of this pit. An 18-T. Orton and Steinbrenner locomotive crane with a bucket of 1¼ cu. yd. capacity and a 50-ft. boom, operates over this trestle, unloads and distributes coal from railroad cars or storage, as well as doing all necessary switching about the power plant.

Coal, for use in the plant, is dumped into the track hopper from which it is fed by means of the reciprocating plate feeder to the crusher. Here the coal is crushed to stoker size and delivered directly to the apron conveyor; it is then conveyed and elevated, by means of the apron conveyor, the bucket elevator and the flight conveyor, to the storage bunker, being withdrawn from the bunker, as required, into the weighing larry. The larry then records the weight of the coal and feeds it directly to the stoker hoppers. The operation is entirely automatic from the railroad cars to the bunker.

The track hopper is 12 ft. wide by 24 ft. long, of the double hopper type, built of heavy steel plate, well reinforced by stiffener shapes and is supported by means of structural steel beams from the pit walls. At the bottom of each branch of the hopper there is provided a double rack and pinion operated gate designed to regulate the flow of coal from the hoppers to the feeder. In this manner provision is made for changing the outlet opening in the hopper to accommodate the different kinds and sizes of coal that may be required.

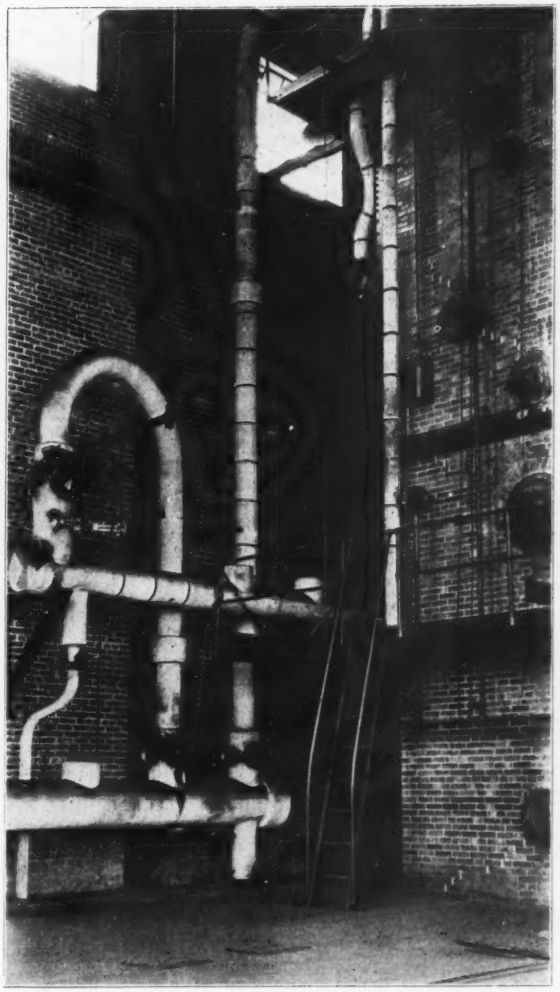


FIG. 10. PIPING ARRANGEMENT BEHIND BOILERS, SHOWING SUPERHEATED STEAM MAIN ABOVE, AND SATURATED STEAM HEADER BELOW

The reciprocating plate feeder is of the double type, of extra heavy steel construction. The feeder plate is actuated by means of an adjustable throw eccentric, operated through gears and countershaft from the crusher roll shaft. The crusher is 24 in. by 24 in. single roll, belt driven type and provided with spring relief plate, adjustable back and safety shearing device, and is supported by heavy structural steel framing. A 30-hp. motor is required for driving the crusher and reciprocating plate feeder. The crusher will handle 14-in. cubes (maximum) and reduce same to 1¼-in. size.

From the crusher the coal passes to the apron conveyor and then to the bucket elevator. The latter is the double strand continuous bucket type and is 77 ft. high between center of head and foot shafts. The elevator consists of 20-in. by 8-in. by 12-in. steel continuous type buckets mounted on two equal matched strands of heavy combination chain. It is entirely enclosed in a heavy steel casing as indicated in the photos, the casing being provided with necessary access and inspection doors and being split at

the head end for easy access to head sprockets and buckets. The drive machinery for the elevator, consisting of a 15-hp. motor with necessary countershafting and gearing, is mounted on an extra heavy structural steel frame supported from bunker and building structure.

Next the coal is delivered to the flight conveyor which in turn delivers it to the overhead bunkers. The flight conveyor consists of heavy steel flights, 14 in. wide, mounted on two strands of steel bar chain. The carrying run operates in a steel trough built up of heavy channel sides with ¼ in. thick steel bottom plate so designed that the bottom plates may be easily renewed without dismantling or in any way affecting the conveyor itelf; the return run of the conveyor operates on steel angle track, such track being tied in the carrying trough to form a single integral frame structure all supported by means of heavy steel frames from the bunker beams and struts.

The weighing larry which delivers the coal to the stoker hoppers is of the motor propelled type, has a capacity of 2000 lb. of coal and consists of a heavy steel hopper suspended through scale beams from a heavy structural steel truck frame. It is propelled by means of a 5-hp. slip ring motor which is provided with a drum type reversing controller, equipped with pendant cords for operation from the boiler room floor level and also with spring release to neutral. Duplex undercut type discharge gate is provided at the bottom of the weigh larry hopper, operated by means of pendant chains from the boiler room floor

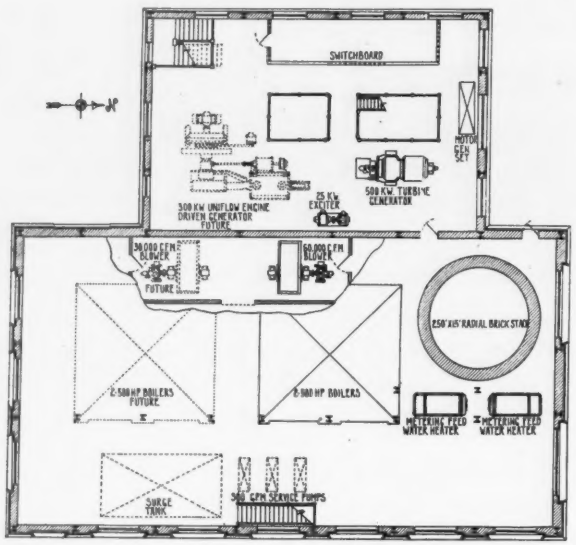


FIG. 11. PLAN OF THE POWER PLANT

level. Coal is discharged through the gate and spout to stoker hoppers. The scale is the ticket recording type, with the balancing beams located in the beam box at a convenient level for balancing and reading from boiler room floor, and all suspended from the larry truck frame. Special provision is made in the weighing hopper and spouts to provide for the use of the weighing larry in laboratory tests by the engineering students of the school.

Special attention is directed to the electrical control of the motors operating the various conveyor units. The motors are all provided with automatic starters, and all motors, except the weigh larry motor, of course, are electrically interlocked to provide for operation in proper sequence, and also arranged so that if any unit is accidentally stopped during operation, all preceding units, feeding coal to it, will automatically stop. By this means the conveyor system must automatically be started in the following sequence:

First: flight conveyor over the bunker.
Second: bucket elevator.
Third: apron conveyor.

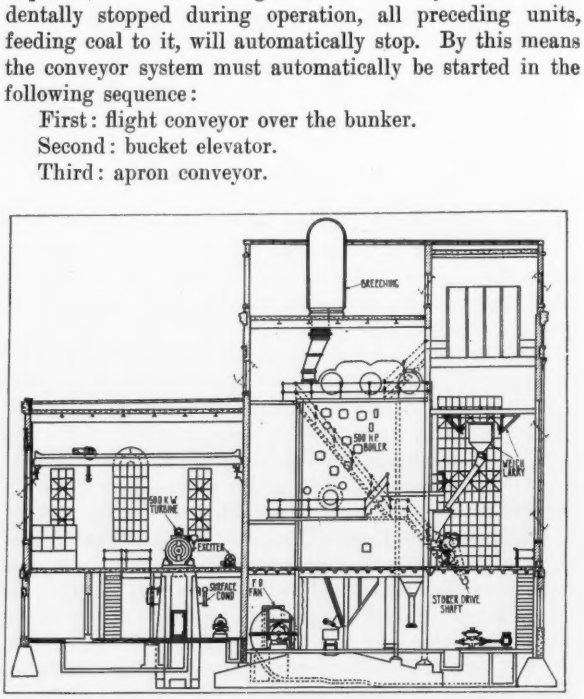


FIG. 12. CROSS SECTION THROUGH PLANT

Fourth: crusher and reciprocating plate feeder.

And vice-versa, if, for example, the bucket elevator should accidentally be stopped during operation, the apron conveyor and crusher and reciprocating feeder will be automatically stopped.

This control system provides absolute safety precaution against the flooding of any one or more units of the system and the consequent breakdowns, which may occur where units are not so interlocked. The main control, with start and stop push buttons, is located at the boiler room floor level; a push button stop station is also located immediately adjacent to each motor so that if for any reason the conveyor system must be stopped on short notice, it can be so stopped from any point in the system.

The capacity of the conveying system as a whole is such as to deliver coal from the railroad cars to the coal bunker, crushing the same to stoker size, at the rate of 50 T. per hr. with maximum size of coal 14-in. lumps. The capacity of the weigh larry is 2000 lb. of coal per dump, the speed of the larry being variable, with a maximum of 175 ft. per min.

The entire coal handling and conveying system was designed, built and installed by Freeman-Riff Company of Terre Haute, Indiana.

An interesting arrangement on the stoker hoppers enables the boiler attendant to see the distribution of coal in the hoppers which are about 10 ft. above the floor and therefore considerably above the eye level. This consists of a small mirror placed at an angle of approximately 45 deg. above the hopper so that the coal in the hopper is visible from the boiler room floor.

Feed water used in the boilers is return from the heating system made up from city water. The make-up is treated in a 3200-gal. per min. Sorge-Cochrane hot process water treating plant which is located in front of the

stack. The chemical solution tank is placed on the ground floor, while the sedimentation tank and filter are located on a platform 13 ft. above the fireroom floor. The space on the firing floor underneath the water treating platform is occupied by one 4000-hp. Cochrane open feed water heater with a V-notch meter. This heater has a capacity of 120,000 lb. of water per hour, heating the water from 90 to 210 deg. This heater is large enough for one-half of the completed plant. A duplicate unit will be installed when the plant is complete.

At present two boiler feed pumps are installed. One is a 3-stage, 300 g.p.m. Worthington Jeansville centrifugal pump, direct connected to an 80-hp. Terry turbine. The other is a 12 by 7 by 12 in. Dean Bros. Co. steam driven plunger pump, fitted with Hills-McCanna force feed lubricator and a stroke counter. Both of the feed pumps are controlled by Fisher governors. Provision is made for the future installation of two centrifugal pumps and one other reciprocating pump.

Stack Is Equipped with Doors for Testing Purposes

Perhaps one of the most interesting things about this entire plant is the stack. This is a 250-ft. radial brick chimney, 15-ft. inside diameter at the top, and was constructed by H. R. Heinecke, Inc., of Indianapolis. It has sufficient capacity to take care of the entire plant when operating at maximum load of 200 per cent rating and is equipped with a soot hopper, gate and spout for discharging soot directly into the ash car. The novel feature of the stack, however, is that it is fitted with 16 inspection doors placed at various points up the stack. These doors are spaced uniformly and are arranged four on a side. Four elevators will be provided to travel along each line of doors so that students may test flue gas velocity, gas temperature, and take gas analysis through any of the doors. This is, so far as is known, one of a few stacks in this country fitted with such an arrangement and it is expected that some interesting and valuable data will be obtained with regard to stack performance.

Ash Handling

Ash is discharged from the steam operated stoker dumps into Allen-Sherman-Hoff ash hoppers. From these hoppers it is delivered by gravity into an industrial car which operates on a narrow gage track in the basement and which serves all of the boilers as well as the soot hopper in the chimney. A Standard platform scale is placed in the track so that the ash cars may be weighed before being discharged into the ash pit outside the building. This scale is shown in the photograph, Fig. 5. The ash is then removed by the locomotive crane to storage or cars.

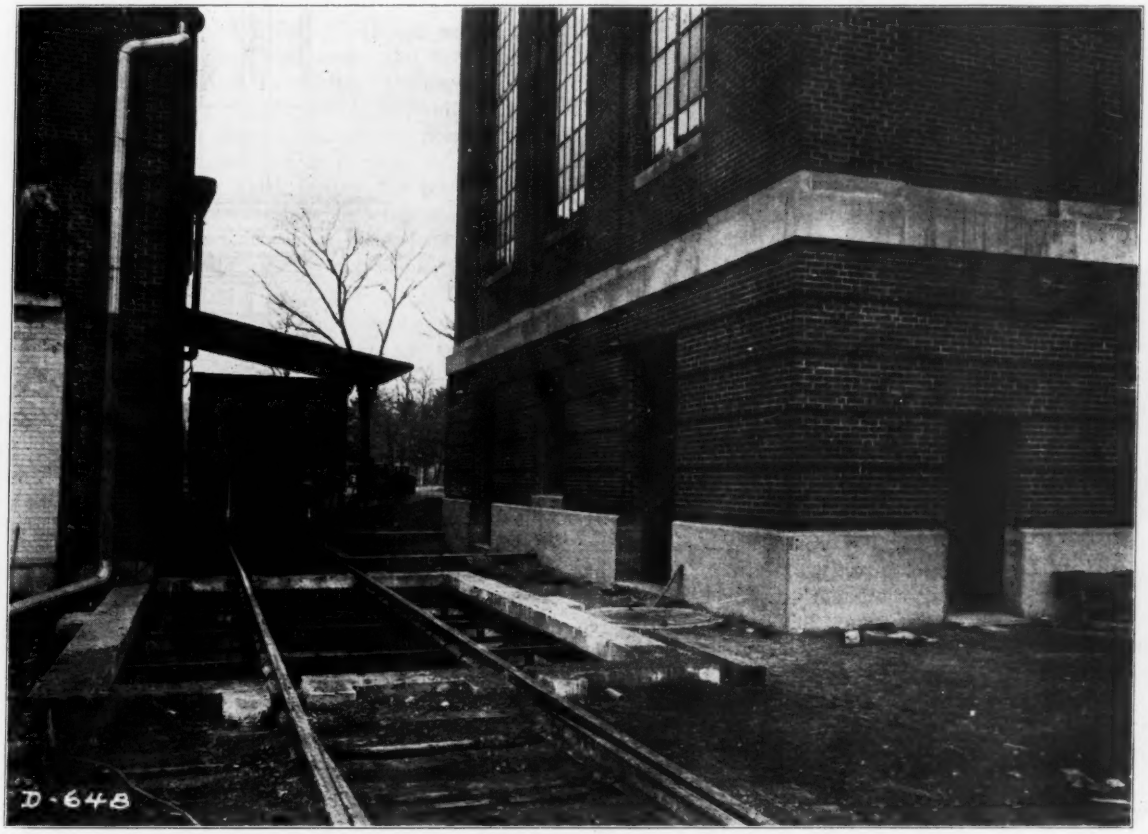


FIG. 13. THE COAL HOPPER DELIVERS TO A CRUSHER BELOW

Features of the Turbine Room

In general appearance the turbine room is exceptionally neat and attractive. It is well lighted during the day by large size windows on three sides of the room and at night by incandescent lamps mounted on RLM reflectors hung from the ceiling. The walls are finished with two-tone cream colored glazed brick and the floors are white mosaic.

The building itself is of modern brick, steel and concrete construction with roof of reinforced gypsum roof tile concrete.

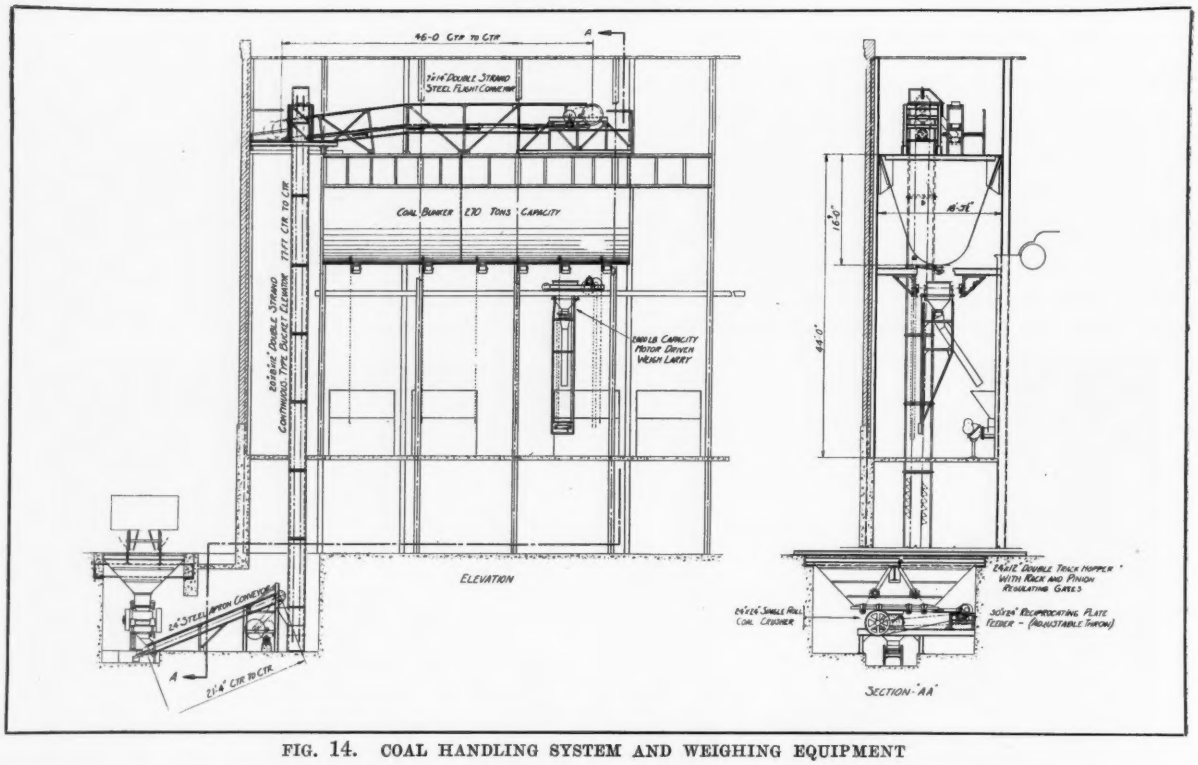

46-0 CTR TO CTR
24'x4" DOUBLE STRAND STEEL FLIGHT CONVEYOR
COAL BUNKER 270 TONS CAPACITY
20 6/16" DOUBLE STRAND CONTINUOUS TYPE BUCKET ELEVATOR
77'7" CTR TO CTR
2000 LB. CAPACITY MOTOR DRIVEN WEIGH LARRY
ELEVATION
24" STEEL APRON CONVEYOR
23'-4" CTR TO CTR
16'-0"
44'-0"
24'x12" DOUBLE TRUCK HOPPER WITH RACK AND PINION REGULATING GATES
24"x24" SWING ROLL COAL CRUSHER
30"x16" RECIPROCATING PLATE FEEDER - (ADJUSTABLE THROW)
SECTION "AA"

FIG. 14. COAL HANDLING SYSTEM AND WEIGHING EQUIPMENT

For handling machinery in the turbine room, there is installed a 10-T. hand operated traveling crane. This crane was installed by H. D. Conkey of Mendota, Ill.

The 500-kw. turbo-generator, referred to in the first part of this article, is installed at the north end of the room, with the condenser directly beneath. The turbine is a five-stage, General Electric Curtis 3600-r.p.m. machine designed for operation on 200 lb. steam pressure, 100 deg. superheat. It is arranged for either condensing or non-condensing operation.

The generator is a 2300-v., 60-cycle, 500-kw., 0.8 power factor, 3600-r.p.m. General Electric unit with the leads brought out for either delta or "Y" connection.

Excitation is furnished by a motor-driven exciter set consisting of a 40-hp., 2200-v., 60-cycle, General Electric induction motor, direct connected to a 125-v., 25-kw., General Electric d.c. generator, operating at 1800 r.p.m. This exciter is located against the wall separating the boiler and turbine room and can be seen at the extreme left in Fig. 6.

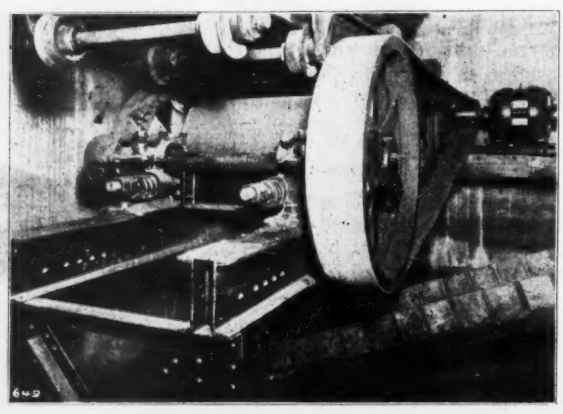


FIG. 15. A VIEW OF THE COAL CRUSHER

Cooling air for the generator is drawn from outside the building through a cleaning room or from the generator room, and is discharged into the blower room, or in cold weather into the turbine room. No air washer is installed at the present time, but the room is available if at some time in the future the installation of an air washer is deemed advisable.

There is also installed a motor generator set for supplying direct current to the laboratories. This is a 225-hp., 2300-v., 60-cycle, General Electric motor, direct connected to a 150-kw., 600-amp., 125/250-v., 1200-r.p.m. General Electric d.c. generator.

The switchboard for controlling the generating equipment and distributing the electrical energy is placed along the west wall of the turbine room and consists of nine panels arranged as follows: No. 1 regulator panel, No. 2 exciter panel, No. 3 exciter motor panel, No. 4 generator panel, No. 5 and 6 blank for future generators, No. 7 tie-line panel, No. 8 synchronous motor panel, No. 9 d.c. motor. Space has been left between panels Nos. 7 and 8 for the future distributors; as the present distribution is from the old plant, this will require seven additional panels. The oil circuit breakers are all of the manually operated remote controlled type, the switches themselves being located in the bus room directly beneath the switchboard.

Condensing Equipment

Although for the greater part of the year the turbo-generator is operated non-condensing, a surface condenser is provided for use in the summer when practically no exhaust steam is needed for heating purposes. This is a Worthington unit with 1000 sq. ft. of cooling surface. The circulating pump is also a Worthington product, consisting of a centrifugal pump direct connected to a 20-hp. General Electric induction motor. The hot-well pump is a Worthington pump driven by a 3-hp. General Electric

motor, and a steam driven rotative dry vacuum pump is provided.

Engine to Be Installed.

Space has been provided at the south end of the turbine room for the installation of a 300-kw. reciprocating engine. This machine, which will be installed in the immediate future, will carry the load at night. At the present time, the turbine is shut down at night and the electrical load carried by the old plant or the local public service company, with which a tie is provided. It is desired, however, to make the plant entirely independent of the power company and the installation of the engine will make this possible. This engine, furthermore, will provide additional facilities for educational work. As a matter of fact, the educational angle also had much to do with the installation of the turbine. Ordinarily, with a unit of this size, better efficiency would be obtained by the use of a reciprocating engine, but it was deemed advisable to sacrifice the slight gain in economy of the engine for the increased educational facility the turbine would afford. The turbine, furthermore, is better able to maintain steady voltage and frequency conditions under the widely varying loads imposed by experimental work in the electrical laboratories.

When the other half of the building is added, another turbine will be installed. This will make two turbines and one engine.

The 150-kw. motor generator, referred to above, is temporarily installed along the north wall of the generating room and will be moved to a permanent location when the second half of the generating room is constructed. There it will be placed alongside a similar machine.

Steam Supply to the Heating System

Because of the extensive area covered by the campus and because of the large number of buildings to be heated, the amount of steam used for heating represents a large part of the total amount of steam produced. The steam for heating is generated at a pressure of about 195 lb. and will be distributed to a number of substations throughout the campus at 150 lb., where it is reduced to a pressure of 3 to 7 lb. for use in the system. The first reduction from boiler pressure is effected in a system of headers in the boiler room. A view of this header system is shown in Fig. 10. There are two main steam headers, one carrying superheated steam and the other carrying saturated steam. The line carrying superheated steam feeds the main turbine and the power plant auxiliary machinery. The saturated steam header feeds only into the heating system. There is a cross connection, however, between the saturated steam header and the superheated steam line so that superheated steam may be sent into the saturated steam line if desired. Saturated steam for the heating system is reduced from boiler pressure to 150 lb. by means of three cross-over connections, two of which are fitted with nozzles and one with a Fisher reducing valve. These connections are shown at the left of the diagram, Fig. 9.

This plant was designed entirely at the University and all material was bought and constructed under the direction of A. A. Potter, Dean of Engineering, G. C. King, Professor of Mechanical Engineering Design, H. L. Solberg, Instructor in Mechanical Engineering, and G. C. Blalock, Assistant Professor of Electrical Engineering.

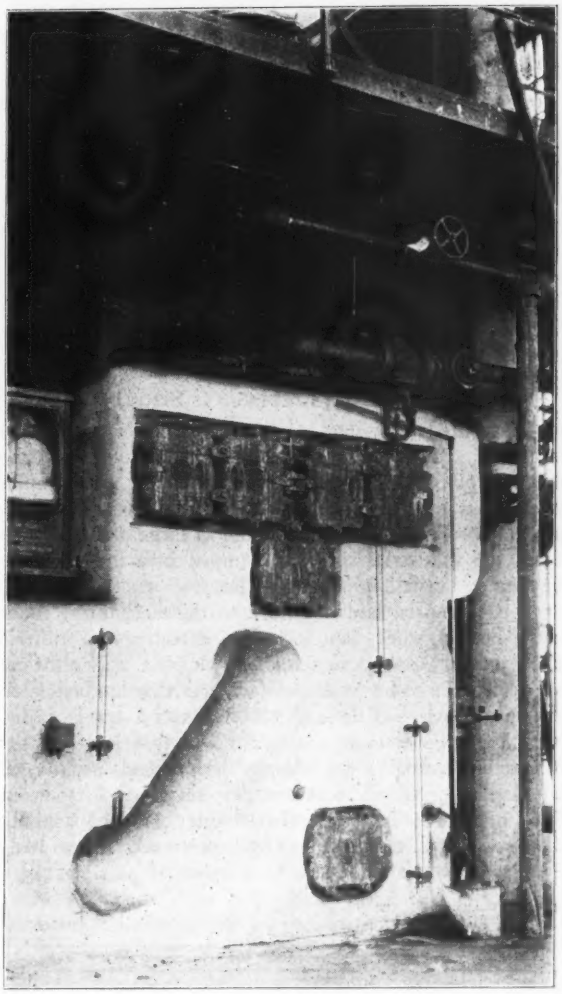


FIG. 16. THE FEED WATER HEATER IS LOCATED ON THE FIRING FLOOR ADJACENT TO THE BOILERS

The building was designed by Nichol, Scholar & Hoffman, architect, Lafayette, Ind. All piping was installed by M. J. Daugherty Co. of Philadelphia. Superheated steam valves are all of Lunkenheimer make, while the saturated steam valves are Chapman. Ehret's pipe covering was used. The breeching was built by the Central Boiler and Sheet Iron Works of Indianapolis and is fitted with expansion joints.

Coal burned at the present time is an Indiana coal with a heat content of about 14,000 B.t.u. per lb. About 90 T. are used per day during the winter months.

Although the turbo-generator is equipped with a condenser, there is no provision at present for supplying cooling water, but a 90 by 110-ft. cooling pond will be constructed this summer north of the coal storage pit. This will not only supply the necessary cooling water for condensing purposes, but will also furnish water for test purposes in the mechanical engineering laboratories.

When complete, the power plant will be one of the most complete and modern of its size in the state. Besides furnishing heat, light and power, it will provide the University with one of the finest power plant laboratories in the country and will be of great value not only for instructional purposes, but for engineering research.

Ash Disposal Methods Demand Attention

Discussion of Several Types of Modern Ash-Handling Equipment, Designed to Improve Operation and Lower Power Costs

IN THE OPERATION of a power plant using coal as fuel, the coal disappears as it is used, but the ash accumulates. Such accumulation cannot usually be tolerated and, during the past few years, some interesting equipment has been designed to convey ash out of the boiler house, to be transported away or to be used near the plant for filling or other construction purposes. It is the purpose of this article to discuss briefly some of the modern types of this ash-handling equipment.

Direct Gravity Method Is Simplest

Elevating the boilers so that cars, either railroad or industrial, can be run underneath them and the ashes dumped directly into the cars, is probably the simplest mechanical ash handling method now in use. This system can be used to good advantage in large plants. Sometimes the industrial cars are dumped into the skip of a skip hoist, as will be explained later.

Little need be said in regard to the mechanical equipment needed when ash is loaded directly into railroad cars. In this case some sort of ash hopper under the ash pit is needed. The principal factor in this method is the ultimate disposal of the ash. Before such a system is laid out, the designer must assure himself that a destination for the ash is always available, as the railroads usually will not haul cars of ash that are not consigned to someone. Care must also be taken that empty cars are available whenever they are wanted. Dead end tracks in the boiler house basement should also be avoided, if possible.

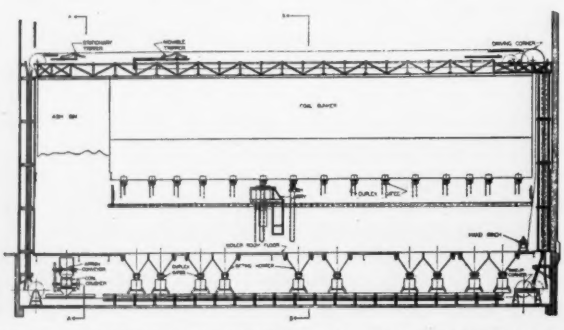


FIG. 1. TYPICAL ARRANGEMENT OF COAL AND ASH-HANDLING EQUIPMENT USING PIVOTED BUCKET CONVEYOR

Another method in extensive use is the continuous conveyor system, arranged to handle both coal and ash. A typical arrangement of this kind is shown in Fig. 1. Here a pivoted bucket conveyor runs through the power house basement as shown. At the left end it receives coal from the coal crusher, the latter being fed from an apron conveyor onto which the coal is dumped from cars or storage pile. The bucket conveyor carries the crushed coal to the bunker above.

Boilers are equipped with ash hoppers, which are emptied onto the lower run of the conveyor at appropriate intervals and on the upper run are emptied into the ash bin, whence they can be spouted to railroad cars or trucks as desired. The conveyor shown in Fig. 1 employs 24-in. by 18-in. buckets running at a speed of 40 ft. per min. It is driven by a 15-hp. motor and has a capacity of 40 T. an hour.

Pan and Flight Conveyors

Figure 2 shows a cast iron pan conveyor, installed to handle the ash from two 1000-hp. Stirling boilers operated at 200 per cent rating. This conveyor consists of a belt of overlapping cast iron pans, suspended between two strands of heavy, long-pitch, steel roller chain. This chain has flanged rollers, which run on T rails. Heavy steel skirt plates run the entire length of the conveyor to insure clean loading and carrying.

With this type of conveyor it is not possible to secure vertical runs, as it is with the pivoted bucket type in the arrangement shown in Fig. 1. It is possible to run the pan conveyor at an incline, or to dump it at a given point into another conveyor running at right angles to it. This type is well adapted to places where the head-room under bin grates is small, as in Fig. 2. At the end of its run it may dump into a hopper, from which a skip hoist can be loaded and the ash taken to a storage bin overhead, or the hopper may load directly into railroad cars.

For horizontal or slightly inclined movement of ash, the flight conveyor is also used to some extent. This conveyor consists essentially of a series of equally spaced flights or plates, drawn through a trough by means of a chain. The flights are perpendicular to the trough and drag the ashes through the latter. Sometimes one chain is used, fastened to the centers of the flights, but the

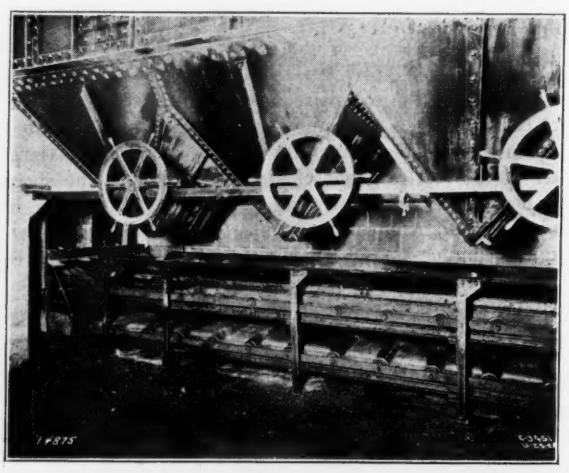


FIG. 2. CAST IRON PAN CONVEYOR OPERATES UNDER ASH HOPPERS WITH LOW HEAD-ROOM

chain may tend to twist about its longitudinal axis, so that better results may be obtained by using two side chains. The entire weight of flights and chain is sometimes carried on wearing shoes which drag on the track. A better method, when two side chains are used, is to provide rollers.

An interesting application of the flight conveyor has been made in a well-known eastern plant. This is illustrated in Figs. 3 and 4. The conveyor runs in a trough filled with water, as shown, the ash pits discharging continuously into the conveyor below the surface of the water. This quenches the ash, prevents dust, lessens wear on the conveyor and effectively seals the ash pit. In this particu-

lar case, the double conveyor is installed, but usually one conveyor is kept as a standby.

With this type of conveyor, when a single flight is used, an auxiliary ash gate can be provided in the ash hopper to discharge into an industrial car, for standby purposes when the conveyor is shut down for repairs. This conveyor may be installed in basements or tunnels only 3 or 4 ft. high.

Monorail systems consist primarily of an overhead track carrying a trolley or carriage on which is mounted a hoist for handling a bucket of ¼-T. to 2 or 3-T. capacity. If electric power is used, the hoist and carriage are made in two forms. One form is entirely controlled from the ground, the operator walking with the carriage as it travels along the track. In the other form, often used for large capacity, a carriage in which the operator rides is attached to the trolley and hoisting and travel are both controlled from this carriage.

Where ashes are to be carried some distance from the plant, the monorail system finds its greatest use. It is especially useful with gas producers or furnaces in which large clinkers or wet ashes are produced. The system should be so arranged that the bucket can be loaded direct from the ash pits and the bucket should be large enough to remove the entire accumulation of ash in one pit at a single loading.

Some Plants Wish to Separate Coal and Ash-Handling Systems

In many plants, it is considered desirable to divorce the coal and ash handling systems. One reason for this is that while little trouble is experienced in handling coal with a chain or pivoted bucket conveyor, the handling of ash with the same conveyor often produces excessive wear on the equipment, owing to the abrasive quality of hot ash. Furthermore, the objection is advanced that, when handling coal with such a system, no ash can be removed and when the latter is being done, the ash must make a complete circuit of the system before reaching the ash storage bin. If separation of the system is logically demanded by the conditions in any given plant, the skip hoist affords one method of removing ash.

This apparatus consists essentially of a bucket running on inclined or vertical tracks and hoisted by means of a steel cable attached to a winding machine. The bucket

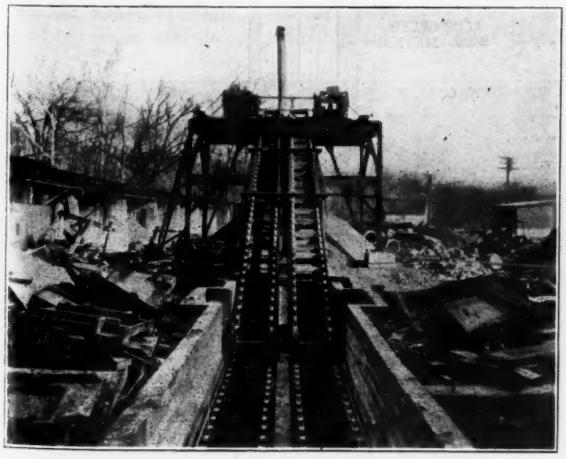


FIG. 4. DISCHARGE END OF CONVEYOR SHOWN IN FIG. 3

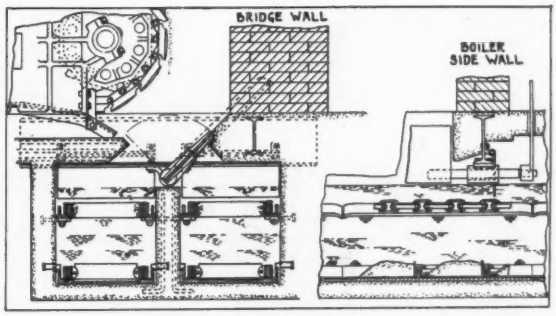


FIG. 3. FLIGHT CONVEYOR RUNS IN TROUGH OF WATER, WHICH SEALS ASH-PIT, QUENCHES ASH AND REQUIRES COMPARATIVELY LITTLE SPACE

consists merely of a rectangular steel box, open at the top and fitted with guide rollers and a hoist bale. The winding machine is usually driven by an electric motor and is usually started by pushing a button; the winding machine hauls the bucket up, it is dumped automatically in the storage bin and returns to the pit.

To fill the bucket of the skip hoist, the usual custom is to provide small industrial cars running on a track directly underneath the ash hoppers. The operator opens the gate, fills the car, pushes it by hand on its track to the skip bucket, dumps it into the bucket and starts the hoist. Then, while the skip bucket is being hoisted and dumped, he can return with his car for another load. Figure 5 shows a skip hoist installation at a large paper mill and Fig. 6 an ingenious method of using the skip hoist, in a small plant, to handle both coal and ash. Skip hoists form one of the commonly used ash-handling devices for large and small plants.

For plants of less than 2000 b.hp., the vacuum ash conveyor and the steam jet conveyor are often installed.

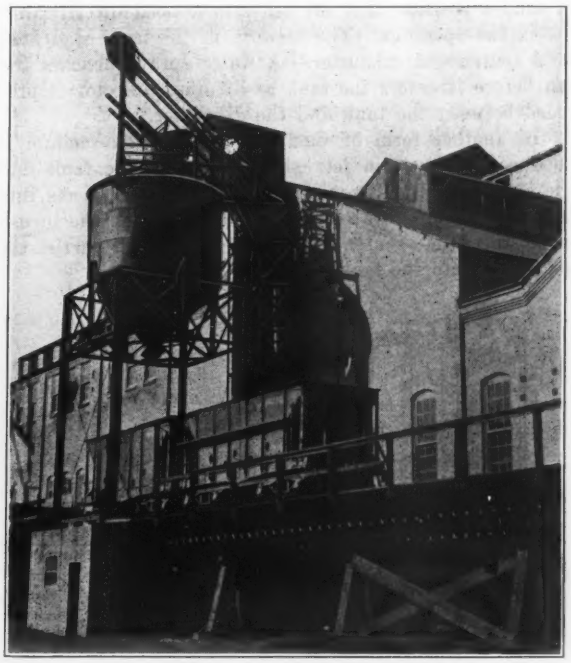


FIG. 5. SKIP HOIST DUMPS ASH INTO OUTSIDE STORAGE TANK, FROM WHICH IT PASSES DIRECTLY TO RAILROAD CARS

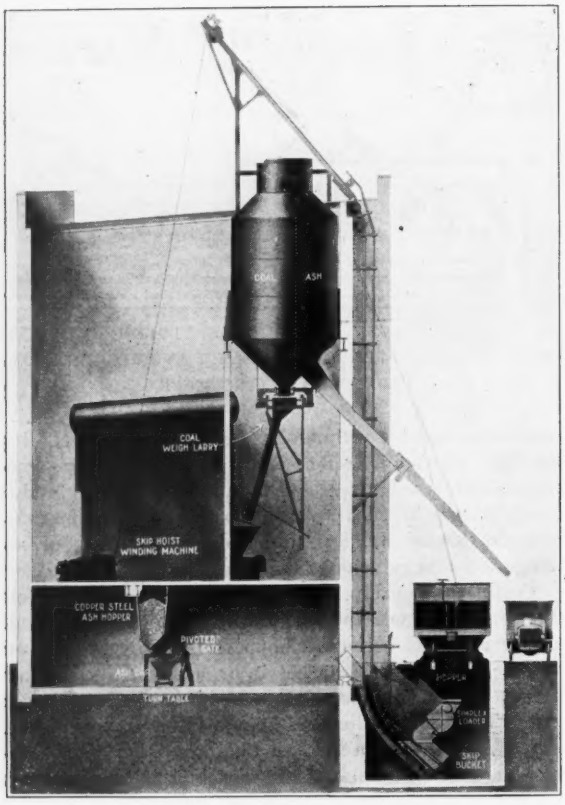


FIG. 6. SKIP HOIST DUMPS EITHER COAL OR ASH INTO STORAGE BIN, IN THIS SMALL PLANT

In the vacuum conveyor, a partial vacuum is maintained in the storage tank, producing a high velocity current of air through the intake pipe, which is run in the ash pit in such a position that the ash can be hoed directly into the intake openings. The vacuum in the tank is created by a centrifugal exhauster. A water spray quenches the ash before it enters the tank and a dust collector is provided between the tank and the exhauster.

In another form of vacuum conveyor, the vacuum is produced by a steam jet exhausting from the tank into the atmosphere. This steam nozzle sometimes ejects into the stack. This draws air out of the tank and the inrush of air from the open end of the conveyor ducts carries the ash along into the tanks.

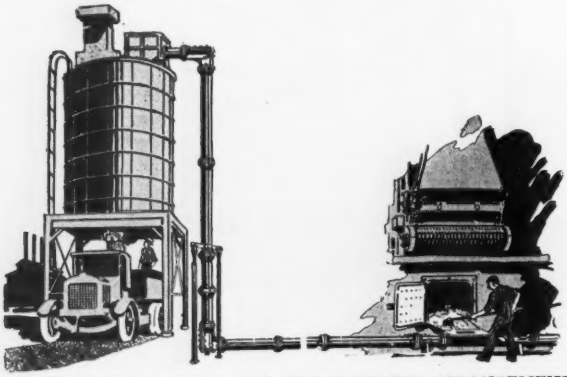


FIG. 7. TYPICAL STEAM JET ASH CONVEYOR ARRANGEMENT, SHOWING STEAM NOZZLE ELBOW AT END OF HORIZONTAL INTAKE RUN

In the steam jet conveyor, a typical installation of which is shown in Fig. 7, a principle different from that of the vacuum conveyor is employed. The pipe line into which the ash is raked through suitable intake openings is located in front of the ash pits, either in the basement or in a trench in front of the boilers, in the case of a small hand fired boiler installation. At the 90-deg. elbow, where the horizontal pipe turns to go up to the ash storage tank, a special fitting, shown in Fig. 8, is provided, to take the impact of the ash and also to carry a special steam nozzle. When steam is turned through this nozzle, a partial vacuum is created in the intake pipe, pulling the ash along; when the ash strikes the steam jet it is forced up the vertical pipe and into the tank. Here the ash strikes a target which reduces its velocity and allows it to settle easily into the tank. Suitable water sprays are provided at the top of the tank to quench the ash and reduce the dust to a minimum, and suitable vents are usually provided. Figure 9 shows an ash storage tank fed by a steam jet ash conveyor installed inside a boiler room. The target box is shown at the top of the tank.

Wherever necessary, auxiliary booster nozzles can be installed in the steam jet conveyor pipe lines, in case the line is unusually long. Elbows and parts taking impact of the ash are usually made of white iron and designed so that the wear is taken on liners that can be renewed.

Sluicing Methods Are Being Developed Rapidly

Where a supply of water is available without much pumping, some method of sluicing ash out of the boiler house may be considered. Figure 10 shows an installation of sectional cast iron sluiceways under air cooled furnace bottoms on pulverized coal furnaces. This sluice is equipped with water-tight access and inspection doors, and the inside is furnished with replaceable white iron liners. A high velocity sluicing nozzle is shown at the end of the sluice. Ash is handled intermittently in this particular installation, with small quantities of water at high pressure.

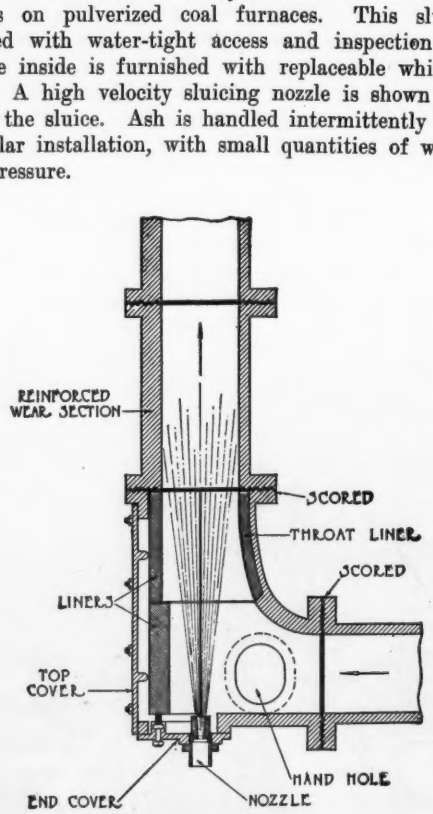


FIG. 8. DETAILS OF 90 DEG. STEAM UNIT FITTING OF STEAM JET ASH CONVEYOR

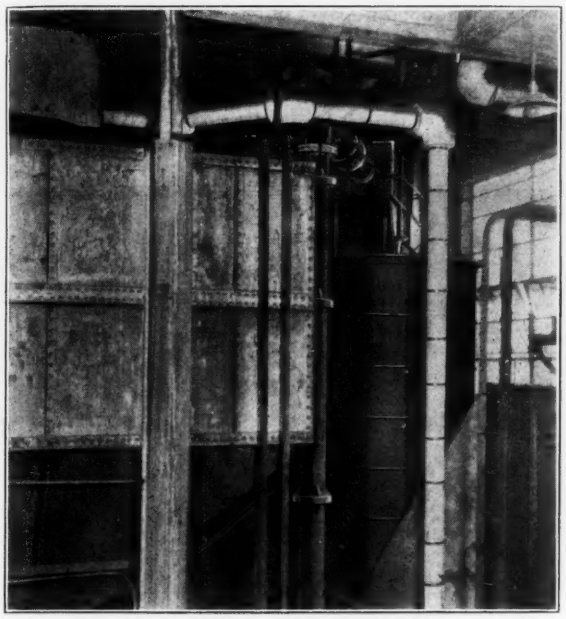


FIG. 9. VERTICAL RUN OF STEAM JET CONVEYOR LEADS TO STORAGE TANK INSTALLED INSIDE BOILER HOUSE

Many of the methods described above can also be used in various ways to remove soot from the soot chambers of a boiler. In doing this, however, arrangements are usually made to prevent the soot from being excessively moistened, as in that case it will stick to the inside of the pipe lines and other equipment.

Ash storage tanks are constructed in a variety of ways. Cast iron, concrete-lined steel, steel, concrete and hollow tile or brick may all be used. In general, it is considered that a cast-iron tank is better adapted to withstand the abrasion of ash than the other materials. Concrete-lined steel also makes a good tank, as repairs can be made to the concrete lining. Steel tanks have proved satisfactory in many cases, although some sort of protective coating must be given the steel. Many concrete storage tanks and hollow tile tanks are in use.

Ash hoppers and ash gates form an important part of the ash-handling equipment. A typical installation of copper steel hoppers and hand operated pivoted gates is shown in Fig. 11. The gates are counterweighted for ease of operation and the operator has full control of them

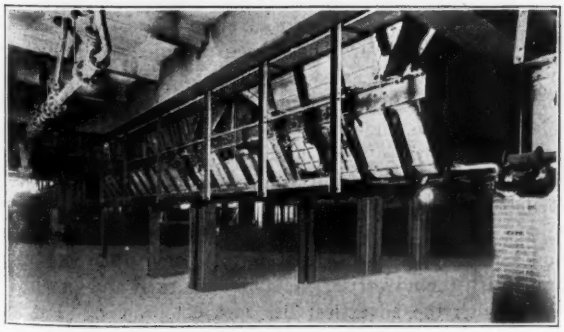


FIG. 10. THIS SLUICE-WAY, INSTALLED UNDER PULVERIZED COAL FURNACES, DISCHARGES TO SUMP, FROM WHICH ASH IS PUMPED

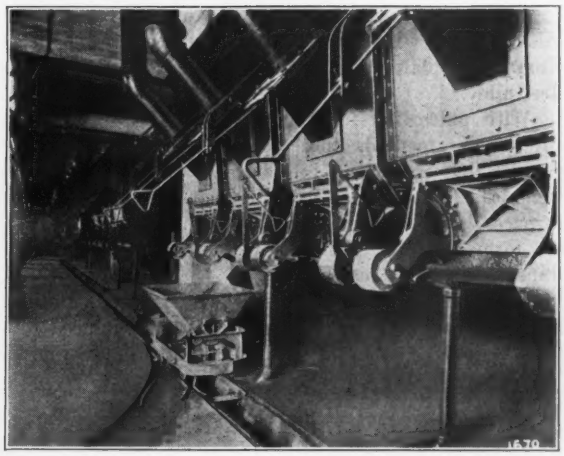


FIG. 11. COPPER STEEL ASH HOPPERS DISCHARGE THROUGH HAND-OPERATED ASH GATES INTO INDUSTRIAL CAR

at all times. In this particular arrangement the ash is dumped into an industrial car and taken to a skip hoist.

Gates are usually counterweighted and furnished with devices for draining the quenching water used in the hopper and are sometimes fitted with water seals. Hoppers may be lined with tile or brick resting on iron ledges, the latter helping to protect the steel against corrosion. Quenchers are often provided as shown in Fig. 12. The water from these quenchers must be disposed of through suitable drains.

Quenching Water Drained From Ash Hoppers Causes Corrosion

In connection with corrosion of ash hoppers, an interesting test has recently been made by the Pittsburgh Testing Laboratories Co. Samples of water discharged from ash hoppers of four large power plants were taken and their corrosive action on cast iron, copper steel alloy (26 to 28 per cent copper) and tank plate, measured by immersing plates of these metals in them repeatedly and measuring the unit weight loss for pieces of like thickness and area. The water was heated to the temperature at which it originally left the hoppers. The following table gives the unit weight losses:

	Water Number			
	1	2	3	4
Cast iron	3.31	2.79	2.19	2.07
Copper steel alloy (26 to 28 per cent copper)	4.47	7.25	5.98	5.95
Tank plate	3.93	6.69	5.94	5.28

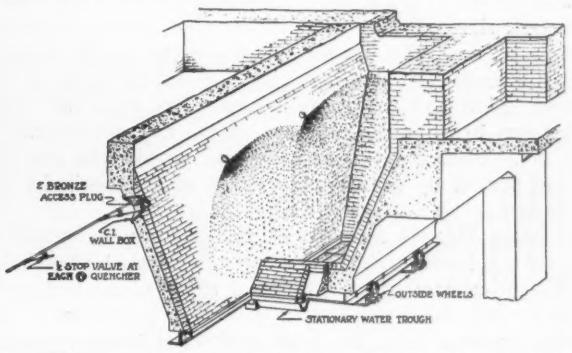


FIG. 12. QUENCHING NOZZLES INTRODUCE WATER SPRAY INTO ASH HOPPER

These results indicate that, on an average, cast iron will withstand this corrosion about twice as long as ordinary tank plate and about 2½ times as long as copper steel alloy.

With pulverized fuel furnaces, ash is disposed of by any of the methods indicated above, sluicing being a method that is coming into more extensive use for this purpose. It sometimes happens that the ash from such furnaces has a fusing point so low that slag and clinker are formed that are difficult to sluice. In this case, a transfer hopper is used.

With pulverized fuel furnaces, arrangements are often made to install cinder separating fans as induced draft fans to remove suspended matter that would otherwise

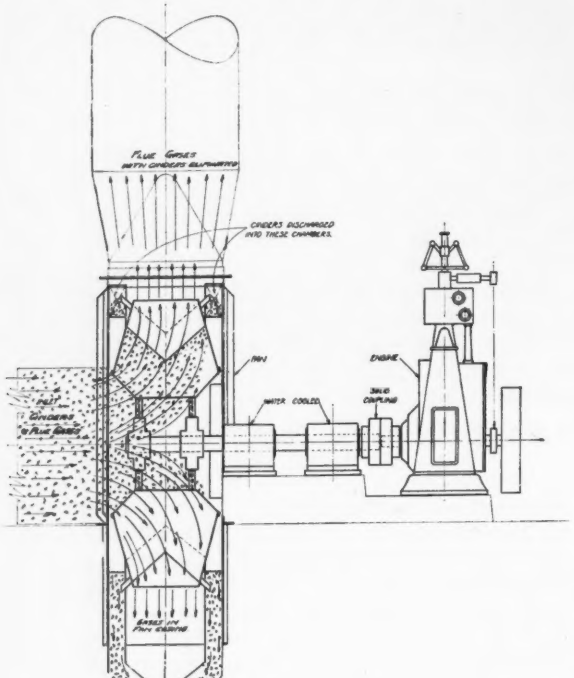


FIG. 13. THIS INDUCED DRAFT FAN ELIMINATES ASH AND CINDERS FROM FLUE-GAS OF PULVERIZED COAL FURNACES

pass out with the flue-gas. A cross-section of one of these fans is shown in Fig. 13. In the type of fan shown in Fig. 14, the baffles for separating cinders are all located in the scroll-case, allowing a fan of standard design to be used. Ash and cinders from these fans must fall into hoppers to be removed by any of the methods described above. Such fan equipment should properly be considered part of the ash-handling system of a pulverized fuel furnace.

Scale Weighs Ash While It Is Being Conveyed

An interesting device for weighing coal or ash while it is being handled on a conveyor either of the belt, pan or pivoted bucket types has recently been brought out. In this conveyor scale, the frame work of the scale supports a freely suspended portion of the track, the loaded and return parts of the conveyor being independently suspended from opposite sides of the scale arms. This automatically deducts the tare or weight of the conveyor itself. The conveyor drives an electric generator through suitable mechanism. The current for this generator, by an arrangement of dash-pots, varies directly with the instantaneous weight of the weight on the conveyor and the

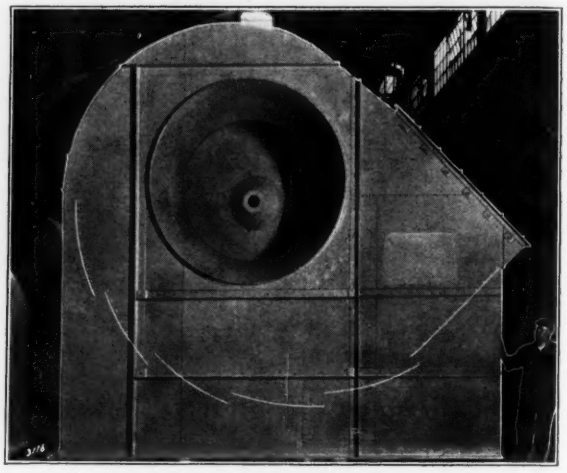


FIG. 14. IN THIS CINDER ELIMINATING FAN, THE BAFFLES FOR TRAPPING ASH AND CINDERS ARE IN THE SCROLL CASE

voltage is directly proportional to the speed. Their product recorded on a suitable wattmeter can be read as the total weight conveyed.

Business Paper Advertising Eligible for Harvard Award

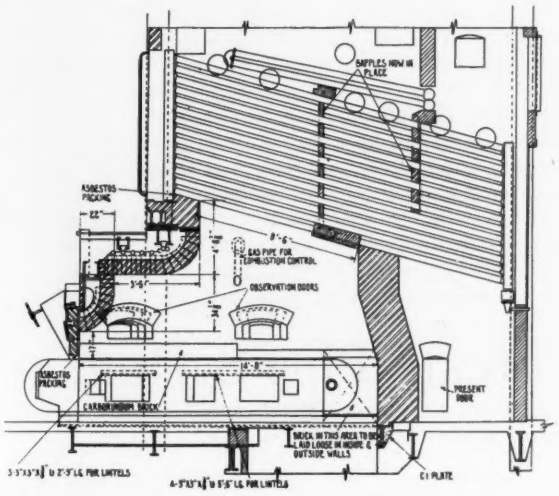
THE COMMITTEE in charge of the Harvard Advertising Awards, founded in 1923 by Edward W. Bok, has issued a statement calling to the attention of industrial advertisers and those using business and trade papers that advertisements or advertising campaigns appearing in the business press are eligible for consideration under the term of the Awards for 1925. In the formal announcement the awards were "restricted to newspaper and periodical advertising in the United States and Canada." Under the ruling of the Committee, therefore, business and technical papers are included under the term "periodicals."

According to the Committee, inquiries from some industrial advertisers indicated that they were uncertain whether their campaigns and advertisements were eligible. While no special awards have been provided for industrial or trade advertising as contrasted with consumer advertising, the industrial advertisements and campaigns are eligible to compete under the classification of awards as set up, which provides three awards of $2000 each for campaigns and research, and three $1000 awards for meritorious individual advertisements. According to the Committee, the Jury will be instructed to consider campaigns and advertisements with especial attention upon the problem which the advertiser faces and the skill and ingenuity with which the advertiser has met his problem. For the current year advertising published during the period from October 1, 1924, to January 1, 1926, is eligible for consideration. Submittal to the Harvard Business School, however, must be made by December 31, 1925.

Results Obtained With a Southwest Coal

IT IS OFTEN FOUND ECONOMICAL TO USE COAL, WHICH MAY NOT BE OF THE BEST QUALITY, FROM FIELDS NEAR THE PLACE OF CONSUMPTION

FORTUNATELY, many sections of the southwest which do not produce oil and natural gas are not a great distance from various grades of coal, many of which are suitable for power plant use. At El Paso, Texas, the El Paso Electric Railway Co. is making good use of a bituminous coal, known as Kinney coal, which is mined from a 4-ft. vein near San Antonio, N. M. The rating of this station is 31,500 kw.



TEST DATA GIVEN HEREWITH WERE OBTAINED AFTER THE REAR ARCH HAD BEEN TAKEN OUT, AS SHOWN ABOVE

Continuous sampling of this coal shows that over a period of a month its proximate analysis is as follows:

	As Received	Dry Basis
Moisture	3.00	0.00
Volatile combustible	32.85	33.87
Fixed carbon	45.80	47.22
Ash	18.35	18.91
Sulphur	0.87	0.90
B.t.u.	11,974	12,345

It is interesting to note that the moisture content is low, being only 3 per cent and the ash content high. The ash melts at a comparatively low temperature but is giving comparatively little trouble at this station.

It has been found that little trouble need be expected from spontaneous combustion of this coal. Coal is received at the plant and immediately crushed to 1¼ in. and smaller before it is placed in storage. It can be stored safely to a height of 18 ft. or even more. When trouble has been experienced, due to firing of the coal in storage, it has been the practice at this plant to remove and use immediately that coal which is affected. If the fire or heated spot is caught in its early stage, water is used to quench it. This coal has a tendency to slack, although not to the same extent as the lignite coals of the same region.

At times it becomes necessary to use other than Kinney coal. When this is necessary the operators are careful not to mix, in storage, the Kinney coal with that from other mines and the daily plant requirements are met from the latter, thus making an effort to keep in storage only the Kinney coal.

All coal which is to be distributed to the boiler bunkers for immediate consumption is moistened as it is unloaded from the cars or as it is reclaimed from storage. Water is added to the extent of about 2 per cent. In accordance with the analysis previously given, the coal as fired then contains about 5 per cent moisture. This has been found advisable when burning this coal on forced draft chain grate stokers. The advantage of wetting the coal before it is delivered to the conveyors is that in the subsequent handling the coal is thoroughly mixed and so the tempering is uniform. Two weigh larries are provided in the boiler room and the bunker gates are so arranged that coal can be withdrawn from any part of the bunker.

Boilers in this plant are rated at 600 hp. each and the stokers have an effective grate area of 132 sq. ft. The front headers are set 11 ft. 5 in. above the floor. The rear furnace wall does not overhang the grate, although it is corbeled slightly to give a gas opening at the first pass of 8 ft. 6 in. Vertical baffles are used to provide for three gas passes across the tubes.

As an indication of the results which are being obtained, the following test data is available:

1. Test of Boiler No.	8
2. Date	5-30-25
3. Duration of test, hr.	8
4. Kind of furnace	Detrick suspended arch, straight bridge wall
5. Grate surface, sq. ft.	132
6. Water heating surface, sq. ft.	6001
7. Kind and size of coal	Kinney slack
8. Steam pressure by gage, lb.	190.6
9. Temperature of feed water to boiler, deg. F.	206
10. Temperature of flue gas, deg. F.	560.5
11. Superheat of steam, deg. F.	140
12. Furnace draft, in. water	0.066
13. Average stoker speed, ft. per hr.	29.4
14. Average steam flow, lb. per hr. (by meter)	28,288
15. Average water flow, lb. per hr.	27,942.7
16. Barometer, in Hg	26.3
17. Air temperature, deg. F.	80
18. Carbon dioxide, per cent	11.9
19. Factor of evaporation	1.138

TOTAL QUANTITIES

20. Weight of coal as fired, lb.	31,084
21. Moisture in coal, per cent	5
22. Weight of dry coal consumed, lb.	29,529
23. Coal analysis, moisture, per cent	5
24. B.t.u. as fired	11,305
25. B.t.u. dry coal	11,900
26. Total weight of water fed to boiler, lb.	223,541.6
27. Total water evaporated, lb.	223,541.6
28. Total water evaporated from and at 212 deg., lb.	254,390.34

HOURLY QUANTITIES AND RATES

29. Dry coal consumed per hour, lb.	3,691.2
30. Dry coal per sq. ft. grate surface per hr., lb.	27.9
31. Water actually evaporated, lb.	27,942.7

32. Equivalent evaporation from and at 212 deg., lb. 31,798.8
33. Equiv. evap. from and at 212 deg. per sq. ft. heating surface, lb.....5.29

CAPACITY

34. Equiv. evap. from and at 212 deg., lb.....31,798.8
35. Boiler hp. developed.....922
36. Rated capacity from and at 212 deg., lb.....20,700
37. Percentage rated capacity developed, per cent...153.9

ECONOMY RESULTS

38. Water fed to boiler per pound of dry coal, lb.....7.57
39. Water evaporated from and at 212 deg. per lb. dry coal, lb. 8.615

EFFICIENCY

40. Calorific value of 1 lb. of dry coal, B.t.u.....11,900
41. Efficiency of boiler and furnace, per cent.....70.2

At from 150 to 180 per cent of rating, which is the usual load carried on the boilers, the following blast pressures are maintained:

Blast box	5	in. water
First zone	.....0.80	in. water
Second zone	.....0.30	in. water
Third zone	.....0.10	in. water
Fourth zone	.....0.00	in. water

The draft at the arch is normally 0.02 in. and at the uptake about 0.60 in. water. The uptake dampers are automatically controlled, whereas the stokers and forced blast fans are under manual control. It has been found that this fuel can be burned most economically if sudden changes of the fuel bed are avoided. All necessary changes are made slowly and so the boilers are never crowded in order to obtain a straight steam line. Droppings at the front of the stoker form but a small per cent of the coal fired and are shoveled into the stoker hoppers without any noticeable detrimental effect upon the fires.

Walls Are Pointed Up With Cement Gun

Carborundum brick is used at the stoker ledge plates. Clinker accumulation at these points is broken off about every 48 hr. Each boiler is taken out of service after two weeks of operation and at that time the clinker accumulation on the tubes is cleaned off and the walls are pointed up with an air gun using a mixture of three parts crushed fire brick and one part fire clay. This mixture is applied after first washing the parts of the wall to be built up with a solution of sodium silicate. Once every 6 mo. the grate bars of each stoker are removed and each link is sand blasted to remove all clinker which may have adhered to them. This is an effective way to keep open the air spaces between the grate bars.

Design of an Efficient Steam Pipe System

Materials Must Be of the Best Quality and Layout Must Be Adequate and Workmanship Good. By C. C. Hermann

IN PREVIOUS articles I discussed in a more or less general manner steam piping as we find it between the boilers and the prime movers. I referred here and there to some differences between the piping system as used for saturated steam and for high pressure superheated steam. In the present article I shall discuss a specific installation of the Waterloo, Cedar Falls and Northern Railroad plant located at Waterloo, Iowa. Steam is generated in this plant at a pressure of 200 lb. ga. and with a superheat of 100 deg. F. This plant consists of six 500-hp. Stirling boilers equipped with Foster superheaters. These boilers operate at from 150 to 200 per cent rating.

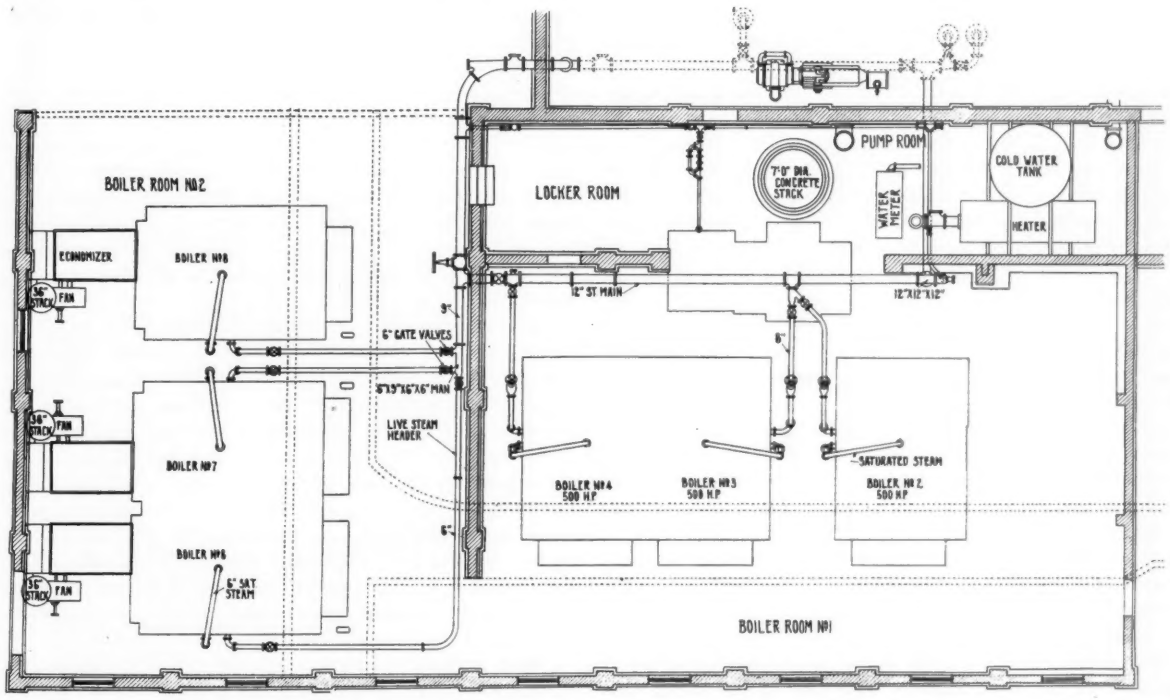
Referring to the plan drawing of the power plant, it will be noticed that the boiler room is constructed in an L shape. Boiler room number 1 is 49 ft. 2⅜ in. by 80 ft. and boiler room number 2 is 53 ft. 3 in. by 66 ft. 7 in. This latter section is provided with a temporary wall, future plans being to duplicate this section, providing space for three additional boilers when needed. This arrangement places three of the boilers at right angles to the other three. The back-to-back plan construction is carried out. The power units are located adjoining both boiler room number 1 and 2. This arrangement provides for the utilization of a loop header.

Each boiler is supplied with a 6-in. saturated steam connection which is piped to the Foster superheater. The outlet connection of the superheater is also 6 in., this size branch pipe being carried to the main header which is 12 in. throughout. Each boiler is supplied with an automatic non-return valve near the boiler and in the branch. A 6-in. gate valve connects the boiler to the header. All fittings and piping are, of course, high pressure or 250-lb. fittings. All ells are long radius. The main steam loop is amply large for considerable expansion of the boiler capacity. It is provided with gate valves so located that any portion of the plant may be closed down without throwing all units out of operation. Boilers 2 and 3 connect with the header through a common tee and flanged lateral reducing in branch and run, whereas boilers 7 and 8 connect to the header by a double sweep tee reducing in the run and branches from 9 in. to 6 in. This illustrates two methods of connecting boilers to the line where the connections come together. The latter method is preferable wherever practical.

At the far corner of the steam header and just to the rear of boiler number 2 is located a drip pocket. The steam header dead ends here, excepting for the boiler feed and other auxiliary pipe being taken off at this point. The auxiliary steam line is 4 in. and connects back into the header at a point somewhat beyond boiler number 8. This line supplies two Knowles 10 by 6 by 12-in. boiler feed pumps and the forced draft engines. The generating units, consisting of two 1500-kw. units and one 3000-kw. unit, turbine driven, are supplied with steam from the far side of the steam loop. All are connected to the header by individual valves and a steam separator of ample size.

Stated briefly, the principal requirements of high pressure steam piping are: 1. Good design. Good design is simply another way of saying efficient design. An efficiently planned piping system, taking into consideration initial cost of the installation, which should be the lowest possible, taking into account flexibility of the system as well as future expansions. The main header must be of ample size to take care of present demands as well as provide an oversize factor sufficient to take care of additions of the future within reason. In the illustration provided we note the care taken in this regard. Future plans embrace an additional boiler, number 1, to the right of pres-

ent boiler number 2. The header has been provided with a tee reducing in the run to 6 in. and blanked for this boiler. Provision has also been made for boilers 9, 10 and 11 by inserting a lateral with reducing run for boiler number 9 and a tee for boilers 10 and 11. These connections are, of course, blanked off for the present. This shows the minimum amount of large size piping in the present installation, that comprising the main steam loop. This portion of the system is large enough for even additional boilers as the plant expands. It illustrates, however, that extensions form a considerable problem in initial designs.



PROVISION HAS BEEN MADE FOR PIPE EXPANSION AND DRAINAGE

Valves Should Be Provided for Flexibility of Operations

Good design, however, embraces more than just ample capacity for extensions contemplated. Proper placement of valves and the take-off for auxiliaries must be considered. Nobody can predetermine at what point trouble may be encountered in the future operation of the plant. Prudence, therefore, dictates that valves shall be placed in the installation at such points as will permit immediate closing off of various units without closing down the plant. In the case of a large railroad system such as the W. C. F. & N., a shutdown would mean considerable loss. This is true of many industrial as well as public utility plants. Flexibility is the watchword of the power plant designer and engineer. In the example cited, no unit of equipment can be pointed out but that it could be shut off without impairing the continued operation of the plant. In plants where the units may operate on saturated steam as well as superheated steam or where the boiler installation is limited to a single or at most to two boilers, a bypass of the superheaters may be advisable. Here, however, the repair of a superheater necessitates the removal of the boiler from the line until the job is completed and reinstalled. The advantage of a bypass of the superheaters is not apparent in this particular design.

Another point that must receive consideration in the design is drainage. My previous article discussed this phase of pipe systems generally; however, we shall at least touch upon this feature again. Drainage in the saturated steam plant is a point of vital importance. This is also true in the superheat plant; however, due to the excess temperature carried by the steam as compared with the saturated steam plant, the condensation is low except in extremely long headers. In the illustration we are dealing with, steam is at 200 lb. pressure and 100 deg. superheat, giving us a temperature of 488 deg. F. We can stand quite a drop in temperature before condensation takes place. Whatever condensation is present in the steam is removed by the separators ahead of the throttle of the prime movers and by the 4-in. line to the auxiliaries. We notice no particular dead ending of any of the lines where quantities of water may collect; in fact, this being a 24-hr. plant, there is little or no opportunity for water to collect in the mains. The live steam would have the effect of reconverting any water collected in the mains to steam and superheating it before reaching the prime movers.

Examination of the drawing shows that the main steam header drops to a lower elevation just back of boiler number 2 and at the diagonal corner just inside of the generator room. The drop is approximately 15 ft. The steam separators, 2 ft. 6 in. in diameter, outside, stand on the basement floor 8 ft. lower than the lowest point of the steam header which runs along just below the main floor of the generating room. Although the drop at the highest elevation of the header is effected by means of a tee, the lower turn to a horizontal is by a long radius bend. A radius of 60 in. is used at this point.

Another important consideration in pipe system design is taken care of thereby, namely expansion. Expansion in the branches is taken care of by the give in the superheater connections to the branch. The steam loop expansion is taken care of by the swing joint method. The line behind boilers 2, 3 and 4 can expand with freedom because of the drop behind boiler number 2 and the right angle section of the header beyond boiler number 8 can expand due to the drop at the corner. The lower parallel sections of the header can expand freely due to the reverse consideration.

Superheated steam velocities are much higher than saturated steam and therefore, as explained in a previous article, vibration of the pipe lines must be avoided by utilizing long radius bends wherever a change in direction of the steam takes place. Due to the excess area of the main header for the service rendered at this time, vibration is not a serious matter, due to the right angle change in direction of the steam travel at several points in the header. It is preferable to have long radius bends at such points as found behind boiler number 2.

The object of superheating steam is not entirely to eliminate condensation in the header and branch pipes, but to increase the economy of the prime movers. If the former were the case, we might argue, why not superheat and then save the money spent in insulating the piping? Much would be lost and nothing gained by such procedure. It is a proven fact beyond argument that a good covering saves its cost in a short period of time. The temperature of the steam must be maintained as high as possible, not only in the piping but in the valves and fittings as well. All parts of the system must therefore be well covered with a high efficiency insulation. Our illustration does not show this feature; however, the writer determined through personal observation that every inch of steam piping was well covered, including the saturated steam connections from the boiler to the setting where it entered to the superheater. The size of the steam line has nothing to do with a decision regarding insulation. Small lines as well as large radiate heat from the steam. True, superheated plants require a smaller investment in piping and insulation, due to the smaller size of pipes that may be employed because of the higher velocity permissible with superheated steam. To cut a hole through a wall just large enough for the bare pipe and run the insulation up to the wall is inefficient. It is better to cut the hole large enough for the pipe plus the insulation and have the insulation continuous. Flanges should be insulated the same as the piping so as to cover entirely the metal surface.

The second principal requirement of high pressure steam piping is first class materials. A power plant friend told me not long ago that he had no success with composition gaskets on high pressure superheated steam, yet I know of a plant in the same vicinity using practically the same gaskets for the same pressure and 50 deg. higher superheat. There is no question but that copper gaskets are better for high pressure and superheat work. Sometimes the copper gasket is in the form of copper rings imbedded in asbestos and there are other types of copper woven gaskets that can be recommended for this class of work. In general, it is best to use a better gasket and save in shut-downs as well as in labor replacing gaskets in large pipe work.

Replacing a gasket sounds like a simple matter to everybody but the power plant man who is called upon to do the work. When the manager is informed that the plant must be closed down in order to replace a gasket, he sometimes looks the engineer over with the expectation of finding him still damp behind the ears. Not infrequently the replacing of a gasket is a major repair and entails the closing down of the plant to effect it. The designing engineer must take this into consideration at all times.

There was a time when standard fittings were used for fairly high steam pressures, but not so today. Operations cannot be risked with standard fittings in the high pressure superheated plant. The best of materials are none too good for valve construction. The seats must withstand considerable wear, but even the best valve may be rendered useless through encrusting materials carried over with the steam and deposited in the valve. The valve may be entirely blameless in connection with troubles affecting the closing. Valves that may be packed while under pressure are generally preferable. These are just a few pointers in connection with valves in the steam lines and they are sufficient to show that the best care and judgment must be exercised in their selection, but that not all valve trouble may be attributed to the valve.

Leaky valves and joints are dead losses in the steam plant and affect materially the economy of the plant. At one point in a steam plant which the writer visited I counted eight joints and valves in a bunch, four of which were spouting steam. Just small streams, but "big ones from little ones grow." A small leak is noticed at some point and a note made of the leak with the intention of giving it the required attention, but before getting around to it again the leak has increased in proportions. A gasket, for example, eats away rapidly after a steam leak once starts. This brings us to the third important phase of the high pressure superheated plant; namely, workmanship of the installation.

Best materials may be employed, the best design may be at hand; but if installed in an unworkmanlike manner all the foregoing avails nothing. A steam fitter pulls up a screw connection until he thinks it is tight because the joint has generated heat without thinking about the possible dirt that was left in the threads. When the pressure is put on, the joint leaks and the work must be done over. The job that can be successfully accomplished in a slovenly manner is yet to be discovered. Cleanliness seems to be a prerequisite in every task that is terminated successfully and applies to the steam fitting work in the same degree as it does to the operation of an engine or other piece of machinery.

For high pressure work the joints are generally ground. This is done so that the surface will be absolutely smooth. How can a steam fitter expect the joint to be tight if it is flopped around in the dirt and slapped together without wiping it off? Screw joints must be thoroughly cleaned and flanged joints properly wiped off.

CORROSION or erosion of the blading in steam turbines is generally the result of one of three causes: dirty feed water, over-treated feed water, or wet steam. All three of these causes are preventable and should never be allowed to exist in any well controlled plant.

ELECTRIC MOTORS should be overhauled, blown out with compressed air, bearings washed out and new oil installed, at least once a year. In locations of severe service this should be done oftener.

New Generator Produces Steam From Water Spray

No Water Drum Needed and Control of Water and Fuel Is Automatic. By Franz Lang*

CONTRARY TO ALL boiler systems which are filled with water to a certain height, the Becker rapid generator has no water content at all. In the ordinary types of boilers steam is generated from solid water, but in the Becker system, completely vaporized water is injected into the tube system, and immediately transformed into steam.

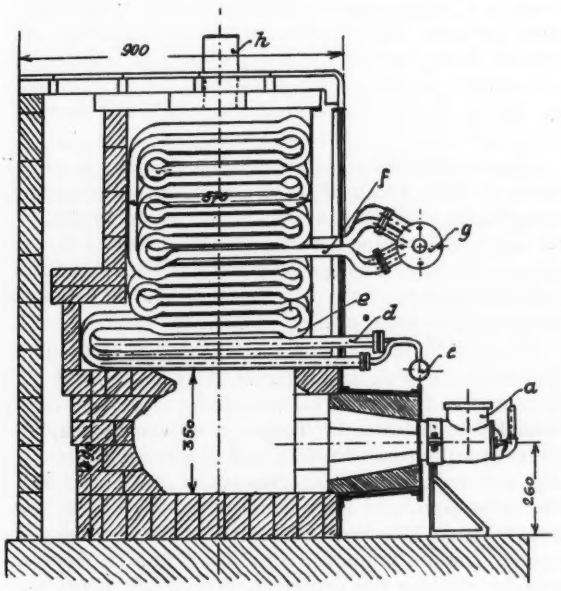


FIG. 1. SIDE ELEVATION SHOWS FURNACE DIMENSIONS IN CENTIMETERS

Consequently, steam is generated the moment the feed water enters the generator, which can furnish power in 3 to 5 min. after starting up, whereas a boiler will require one or more hours under the most favorable circumstances.

Figure 1 shows a side elevation of Becker rapid generator and furnace, equipped for oil burning. The oil is vaporized by a blower (a) and an automatic pump forces the water through the water tube (c) in the pipes (d), where it is forced into a rotary movement and vaporized. This water vapor is immediately transformed into steam in the coils which are enveloped in the combustion gases. The steam rises in the pipes (e) and is led back to the vicinity of the fire zone to be dried and superheated. Then it passes through the exit pipe (f) into the steam reservoir (g). A front elevation of the generator and furnace is shown in Fig. 2.

Constant attention is unnecessary. Oil and water feed are respectively regulated automatically by steam and water pressure. Dangerous results of an explosion are minimized, because the tube system contains no water but only steam and if a tube bursts only the steam contained in it can escape, so that there is not such a strong explosive force present as originates in other boilers from the additional steam generation from water when the pressure is relieved.

The Becker generator has the advantage of low first cost, small space and, if oil is burned, no stack is required. The space occupied by a Becker generator is only 1/40 of the size of a tubular boiler of similar capacity. All parts are easily replaceable without great loss of time. The tubes do not become red hot, as the system provides intensive cooling of the tube walls. If good materials are

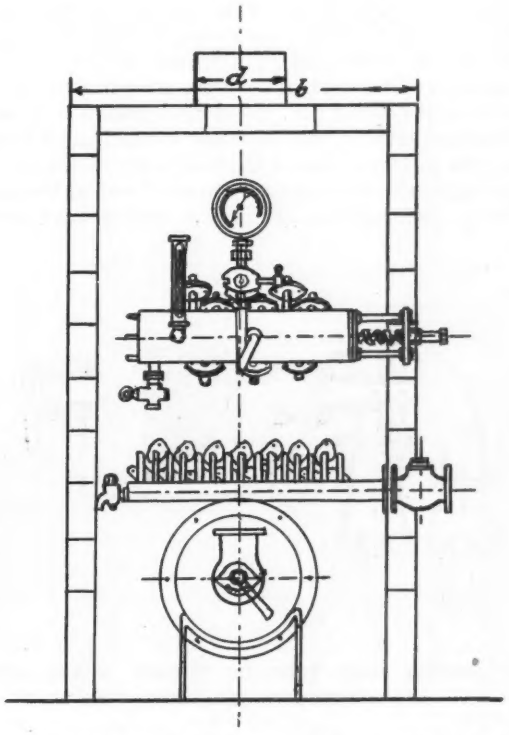


FIG. 2. FRONT ELEVATION SHOWS STEAM RESERVOIR, WATER INLET VALVE, OIL BURNER AND AIR REGISTER

used it practically guarantees long life, absolute operating safety and adaptability even to irregular operating conditions.

The problem of boiler scale formation is solved insofar as there is no crystalline scale. Ordinarily this occurs in the heating of water having more or less sluggish motion. Here, however, the water is transformed immediately into vapor while moving at high speed. Consequently, the scale is not crystalline, but is in the form of a fine dust which settles in the lowest tube sections of the generator. The lowest tube is extended beyond the rear wall of the generator and may be opened from time to time by removing two screws, so that the tube section may be taken out and cleaned. This is done by brushing and takes no more than two or three minutes.

Low grade oils are recommended for fuel, although the generator may also be equipped with grates for coal, turf, wood refuse and other solid fuels.

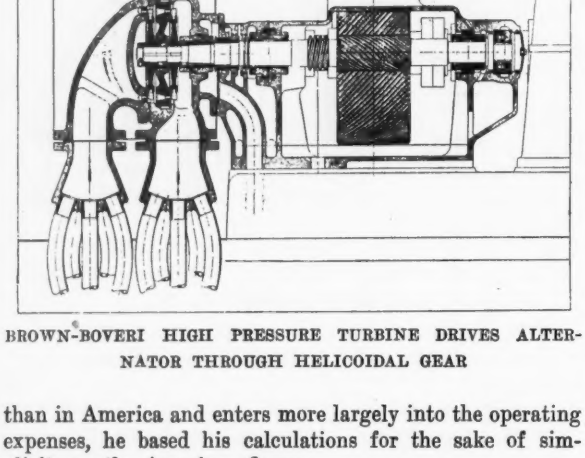
Its possibilities appear to be particularly interesting wherever steam is needed at irregular times or, because of its rapid action, for peak loads. In new installations, or where plants are being remodeled and where exhaust steam is not utilized, high pressure installations of 450 to 1500 lb. have been successfully tried out.

* Engineer Vienna Institute for Scientific Auxiliary Work.

Swiss Developments in High Pressure Turbines

HIGHER PRESSURES AND TEMPERATURES AND USE OF BACK PRESSURE TURBINES ENABLE STEAM PLANTS TO COMPETE WITH WATER POWER. BY CHARLES J. WEBB

AT A RECENT meeting of the Association of Swiss Electrical Engineers in Berne, M. Ad. Meyer, chief engineer of Brown, Boveri and Co., Baden, read a paper on recent installations of high pressure steam turbines, in the course of which he pointed out that at the present price at which it is being offered for delivery in large quantities at Basle, coal as fuel could successfully compete with water power in the generation of electrical energy even in Switzerland. The author stated that, according to various authorities, the cost of fuel, including depreciation, general expenses and interest, was estimated in the United States to amount to 75 per cent of the total costs, in the case of power stations with an annual output of several thousand kilowatts. Although in Switzerland coal is more costly than in America and enters more largely into the operating expenses, he based his calculations for the sake of simplicity on the American figure.



BROWN-BOVERI HIGH PRESSURE TURBINE DRIVES ALTERNATOR THROUGH HELICOIDAL GEAR

At the present time, boilers are being constructed in Switzerland to deliver steam at a pressure of about 515 lb. per sq. in. and a total temperature of about 750 deg. F. His company, in utilizing steam at this pressure, were now able to supply turbines under a guarantee that using coal developing 13,500 B.t.u. per lb. and with a suitable condensing installation the fuel consumption would not exceed 1.06 lb. per kw-hr. at the generator terminals estimating coal at about $7.76 per metrical ton or $7.03 per short ton, the cost was equal to only 0.365 cents. (At the present rate of exchange 100 centimes equal approximately 19.4 cents.)

Figured on the 75 per cent basis mentioned above, the total operating cost of a high-pressure steam operated power station would be only 0.485 cents per kw-hr. for a coefficient of current utilization of 60 per cent, by which is meant the proportion of current supplied during the 12 mo. to the station capacity with all the generators working at full load for 8700 hr. With a coefficient of 40 per cent, the production costs of a steam station would be 0.708 cents per kw-hr. and with a coefficient of only 20 per cent 1.05 cents, figures which in the author's opinion could be favorably contrasted with those of a hydroelectric station. Such figures could, however, be attained only by the adoption of a much higher steam pressure than had hitherto been in general use.

Taking into consideration the large quantities of coal that would need to be imported, it might be questionable whether, in such countries as Switzerland, it would not be preferable to rely on hydroelectric stations. There are many instances in which steam at fairly low pressures is needed; here it is undoubtedly economical to produce steam at a higher pressure than necessary for heating and other purposes, the reduction of the available heat being brought about by utilizing it for operating turbines. An installation of this kind had recently been completed at the Brown-Boveri Works in Baden which will shortly be heated throughout by exhaust steam.

This installation comprises boilers designed to produce steam at from 220 to 270 lb. per sq. in. pressure and a temperature of 662—716 deg. F. for power purposes and for the turbine testing department. The steam is first used to run a turbine, the expansion being there utilized to the condensation pressure and the latent steam heat being then transferred to the condenser circulating water.

In order to meet the heating requirements which vary in accordance with the external temperature, the water must emerge from the condenser at a temperature ranging from 122 to 194 deg. F. Taking as a typical example live steam at a pressure of 265 lb. and at a temperature of 662 deg. and an absolute back pressure of 7.5 lb. per sq. in., the water circulated for heating purposes could be heated up to about 175 deg. Under these circumstances each pound of steam would contain 1350 B.t.u. In the case of an ideal turbine the expansion (adiabatic) would absorb 300 B.t.u. from the steam, leaving 1050 B.t.u. per lb. in the exhaust steam available for heating purposes. In practice, however, the author points out that, taking turbine efficiency at 74 per cent and having regard to mechanical losses and the energy lost by radiation, the heat units actually converted into mechanical energy by the turbine would only be 212 B.t.u. This would leave 1140 B.t.u. per lb. in the exhaust steam or 85 per cent of the energy of the live steam.

With a turbine steam consumption of 15.5 lb. per kw-hr. and a boiler having a vaporization coefficient of 8.75, the fuel consumption would be equal to 1.75 lb. per kw-hr. Owing to the relatively high temperature at which the condenser water utilized as feed water reaches the boiler, such a favorable vaporization coefficient could be expected without demanding too high a boiler efficiency which under such conditions would not exceed 77.5 per cent. With coal at $9.71 per metrical ton, the 15.5 lb. of steam per kw-hr. would cost 0.775 cents. As only 18.5 per cent of the useful energy is taken for power purposes, however, the remainder being utilized for heating purposes, the cost per kw-hr. would fall to approximately 0.145 cents.

Double utilization by back pressure turbines of the energy of steam is rendered difficult by reason of the fact that the demands for calorific energy and of driving power do not always exist in the requisite ratio, and whether one desires it or not, means must often be provided for storing up one of the forms of steam energy. The usual meth-

ods being somewhat onerous and low in efficiency, the plan has been tried of using a direct-steam driven turbine in place of the back pressure type. In this way only a portion of the steam supply is utilized in the turbine to a point of expansion at which the pressure and temperature correspond to the heating installation requirements, the other portion being allowed to expand on its way to the condenser. In this way it is possible in periods of excess power demands to draw steam for the turbine from the condenser steam supply. Inversely, when a greater amount of steam is required for heating than for power, the lower steam pressure stages of the turbine can be cut out and the still live steam, the pressure of which is reduced by a bypass valve, exhausted into the heating system piping.

Since they have commenced the construction of steam turbines, the author states that Brown, Boveri and Co. had supplied normal condensing plants to the extent of roundly 4,000,000 kw. An analysis of these showed the average live steam pressure to be 175 lb. per sq. in., although in certain cases 300 lb. had been attained, the steam temperature, however, never exceeding 707 deg. F.

Progress is now being made in the direction of higher pressure. The North Tees (England) station has for some years been operating turbines with steam from Babcock boilers at 485 lb. per sq. in., 700 deg. total temperature and 370 C. A paper mill in Sweden was equipped with two Atmos boilers, one working at 735 lb. and one at 1500 lb., while two 1200 lb. plants are in course of construction in the United States.

Finally, the author mentioned that Brown, Boveri and Co. had lately completed a 1750-kw. turbo alternator for the electric power station of the Societe des Centrales Electriques des Flanders at Langerbrugge, Belgium. The machine which is at present being tested, is designed to utilize steam at a pressure of 750 lb. and a total temperature of 825 deg. F. The turbine runs normally at 3000 r.p.m., but drives the alternator by means of gearing at 1500 r.p.m. The author stated that in his opinion there is a big future for the joint operation of electric power stations and steam heating and cooking installations, which, with high pressure steam, could be operated on an extremely economical basis.

Performance-Chart for Centrifugal Pumps

By Charles Fromm

BY THE use of the accompanying chart the relations between the characteristic data of centrifugal pumps for fresh water of 70 deg. F. may be determined graphically. The chart is especially adapted for use in the field, where figuring by slide rule may be inconvenient or may take too much time. The formulas used in the design of the chart are as follows:

$$\text{I. Output} = \frac{\text{Capacity} \times \text{Total Head}}{3960} = \text{W. HP.}$$

$$\text{II. Efficiency} = \frac{\text{Output}}{\text{Input}} = \frac{\text{W. HP.}}{\text{S. HP.}}$$

In these formulas the capacity is given in gallons per minute, the total head is in feet, W. HP. is the water horsepower and S. HP. is the shaft horsepower. Scale No. I shows g.p.m.; No. II, feet head or its equivalent pounds per square inch; No. III, the water horsepower; No. IV, the shaft horsepower; and No. V, the efficiency.

Example I. A centrifugal pump delivers 1000 g.p.m. water against a total head of 231 ft. at 80 per cent efficiency.

What is the W. HP. and what is the S. HP. of the prime mover?

Answer: A straight line from 1000 on the capacity scale No. I to 231 on the head scale No. II cuts scale

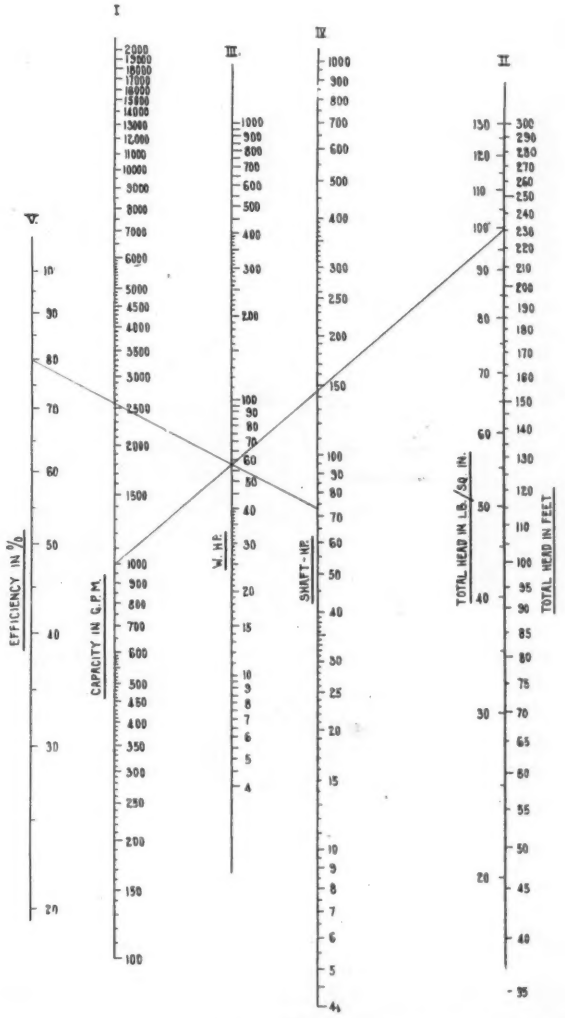


CHART FOR CALCULATING CENTRIFUGAL PUMP PROBLEMS

No. III at the required W. HP., 58.2. A straight line from 58.2 on the W. HP. scale No. III to 80 on the efficiency scale No. V cuts the S. HP. scale No. IV at the required S. HP., 73.

Example II. A centrifugal pump delivers 6000 g.p.m. water against a total head of 100 ft. and required 179 S. HP. from the prime mover.

What is the W. HP. and what is the efficiency of the pump?

Answer: A straight line from 6000 on scale No. I to 100, total head in feet, on scale No. II cuts scale No. III at the required W. HP., 152. A straight line from 152 on scale No. III to 179 on scale No. IV cuts scale No. V at the required efficiency, 85 per cent.

New Type of Fuel Valve for Oil Engines

PRIMARY AND SECONDARY COMBUSTION CHAMBER INSURE EFFECTIVE ATOMIZATION OF FUEL. BY HENRY POKORNEY

ONE OF THE latest developments in oil engine practice, recently patented by the author, is a novel design of fuel valve for engines of the high compression type. It may be used with both 2 and 4-cycle engines, either vertical or horizontal.

The construction is unique and consists of primary and secondary combustion chambers which have a marked influence on the operation of the engine, so that detonations are entirely eliminated, starting is easy, even when cold, and variation in speed is less than 2 per cent in 100 revolutions.

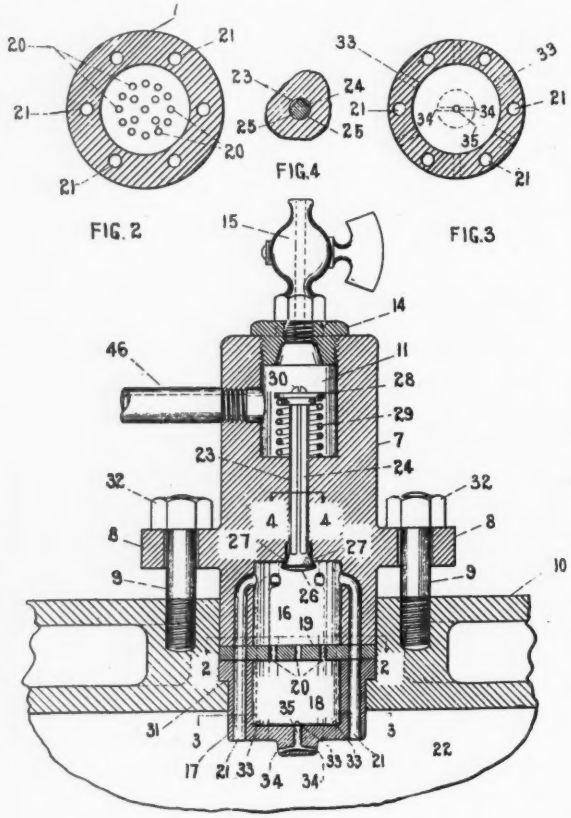


FIG. 1. SECTIONAL VIEW OF VALVE SHOWS PRACTICAL EMBODIMENT OF PATENT

FIG. 2. CROSS-SECTIONAL VIEW THROUGH VALVE SHOWING DIVIDING WALL

FIG. 3. CROSS-SECTIONAL VIEW THROUGH BOTTOM OF SECONDARY CHAMBER

FIG. 4. CROSS-SECTIONAL VIEW THROUGH STEM CONNECTING PRIMARY AND SECONDARY CHAMBERS

Details of the features of this valve are shown in Fig. 1, given as a longitudinal sectional view. Figures 2, 3 and 4 are sectional views taken on lines 2-2, 3-3 and 4-4, respectively. Referring to the small numerals, 7 is a cylindrical body carrying lugs 8 through which pass the studs 9; 10 represents a portion of the cylinder head of the engine, the studs 9 being threaded therein as shown.

The upper end of the valve body 7 is provided with a chamber 11 into which enters the fuel supply pipe 46. The upper end of the chamber 11 is closed by a cap 14 which carries a pet cock 15. The lower end of the valve body 7 is provided with a primary fuel chamber 16. Fitted into the cylinder head 10 is a casing 17 which forms a secondary fuel chamber 18. A diaphragm 19 divides the chambers 16 and 18 and is provided with perforations 20.

Holes 21 are provided, which lead from the combustion chamber 22 of the engine, to the chamber 16, passing through the walls of the casing 17, through the diaphragm 19, and through the valve body 7 as shown.

A hole 23 forms communication between the chambers 11 and 16. Into the hole 23 is fitted a valve stem 24 which is square in sectional shape as shown in Fig. 4, thereby providing channels 25 through which fuel oil may pass from the chamber 11 to the chamber 16. The valve stem 24 carries a valve head 26 which operates to open and close the hole 23, a seat being formed at 27 in the usual manner.

Valve head 26 is normally held closed, as shown, through the valve stem 24, washer 28, and spring 29; the washer 28 being firmly fixed to the valve stem 24 by the screw 20.

Valve body 7, diaphragm 19, and casing 17, are firmly clamped to the cylinder head 10, between the shoulder 31 and nuts 32.

Holes 33 and 34 are provided in the walls of the casing 17, to form a communication between the chamber 18 and the combustion chamber 22 of the engine; the holes 34 lead into the hole 35 which communicates with the chamber 18 as shown. It is preferable that the sectional area of the hole 35 be just equal to the total area of all the holes 34.

FUEL SUPPLY CONTROLLED BY PUMP

Preferable means for supplying fuel to the valve, and for controlling the quantity thereof, is represented in Figs. 5 and 6 where the former is a longitudinal section embodying the valve represented by Fig. 1, and the latter illustrates a side elevation of the speed control lever. Referring again to the small numerals, 36 indicates the valve represented in Fig. 1 as mounted to the cylinder 10, 37 is the piston of the engine and in conjunction with the cylinder 10 forms the combustion chamber 22; 38 is the connecting rod through which the piston 37 co-acts with the crank shaft 39 in the usual manner.

Valve 12 operates from the movement of the cam shaft 40 and cam 41. The cam shaft 40 may be driven from the crank shaft 39 through any form of transmission device suitable for such purpose, many of which are well known in oil engine practice. The valve 12 may serve as both the air inlet and exhaust valve, or an additional valve may be provided in which they would act individually as an air inlet valve, and an exhaust valve.

Cam shaft 65 carries the cam 42 and is driven from the crank shaft 39 through the spur gears 43 and 44.

A fuel pump 45 is mounted on the crank case 49 and is provided with the usual inlet and exhaust check valves. A pipe 46 connects the exhaust end of the pump 45 with

the chamber 11 of the valve 36. A pipe 47 connects the inlet side of the pump 45 to any source of fuel oil supply.

Lever 50 is mounted on a pivot pin 48 which is carried by the crank case 49. One end of the lever 50 carries a cam roller 52 which is adapted to co-act with the cam 42, and the opposite end is provided with a handle 53.

Piston 54 of the fuel pump 45 is connected to the lever 50 through connecting link 55. The spring 56 normally holds the piston down and the cam roller 52 against the cam 42 through the pin 51, lever 50, connecting link 55, and the head end 57 of the piston rod 54.

Reciprocating motion is imparted to the piston 54 by the movement of the crank shaft 39 through spur gears 44 and 43, cam shaft 65, cam 42, cam roller 52, pin 51, lever 50 and connecting link 55.

If it is necessary to reciprocate the piston 54 when the engine is not in operation, the same may be accomplished by hand through the handle 53, lever 50, and connecting link 55. In all cases the piston 54 is returned to its normal down position by the spring 56.

As a preferred means for altering the stroke of the piston 54, a cam shaped lever 58 is provided and adapted to engage under the lever 50 as shown at 59 in Fig. 6. The lever 58 is pivoted on the pin 60 and carries a handle 61. A locking pin 64 is provided, which is carried by the lever 58 and adapted to engage with any of the holes 62 in the crank case 49, thereby locking the lever 58 in various positions. It is apparent that by locking the lever 58 in certain positions, the cam shaped portion 63 will limit the downward movement of the lever 50 to the extent required, for regulating the reciprocating movement of the piston 54.

Atomization and Combustion Effected in 2 Stages

Operation of the engine and valve is as follows: Fuel pump 45 is timed so that an injection of fuel oil will be introduced into the valve 36 once during each suction stroke of the engine. For changing the speed of the engine the quantity of fuel injected by the pump into the valve 36 is changed; this is accomplished by changing the stroke of the piston 54 as previously described.

The fuel oil enters the valve 36 through the pipe 46; first entering the chamber 11 and raises the valve head 26 from the seat 27, through the pressure produced by the pump 45 in the fuel oil. A quantity of fuel oil, equivalent to that displaced by one stroke of the piston 54, will then enter the chamber 16, and fall on the surface of the diaphragm 19, filling the holes 20 but will not pass through on account of capillary attraction; then, as the pressure in the cylinder increases during the compression stroke, air is forced through the holes 21, into the chamber 16, and through the holes 20, carrying with it the fuel oil into the chamber 18; at the same instant hot air from the combustion chamber also enters the chamber 18 through the holes 33 and 34 and meeting the fine sprays of fuel oil, intermixes and vaporizes.

As the temperature of the compressing air increases, it causes the vapors to gasify, and finally ignites through the holes 33 and 34.

An important feature in connection with this valve is that the volume of the chamber 18 should be considerably less than that of the combustion chamber of the engine, so that sufficient air cannot be contained in this chamber for complete combustion of all the fuel, then after the primary flash of ignition, the gases formed in the chamber 18 cannot burn until they escape into the combustion chamber of the engine; also the fact that the holes 33 and 34 are very

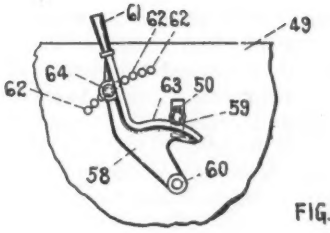


FIG. 6

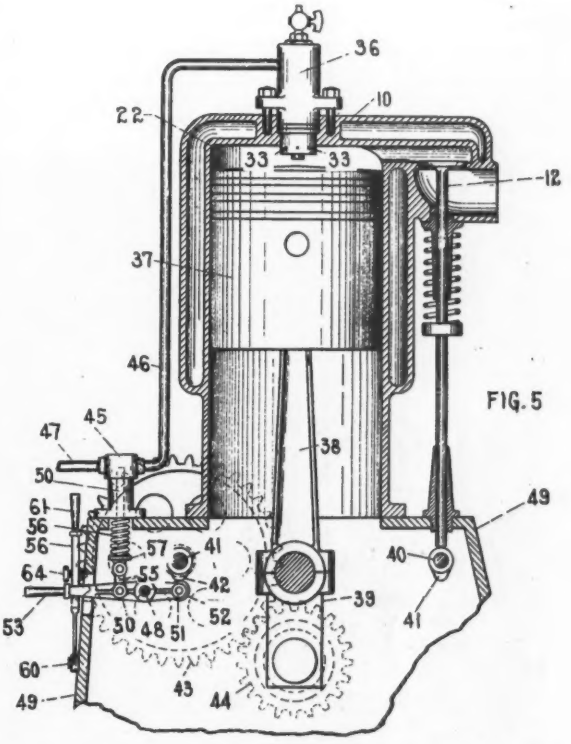


FIG. 5

FIG. 5. LONGITUDINAL SECTIONAL VIEW SHOWING CYLINDER AND PISTON WITH VALVE AT TOP

FIG. 6. SIDE ELEVATION OF SPEED CONTROL LEVER

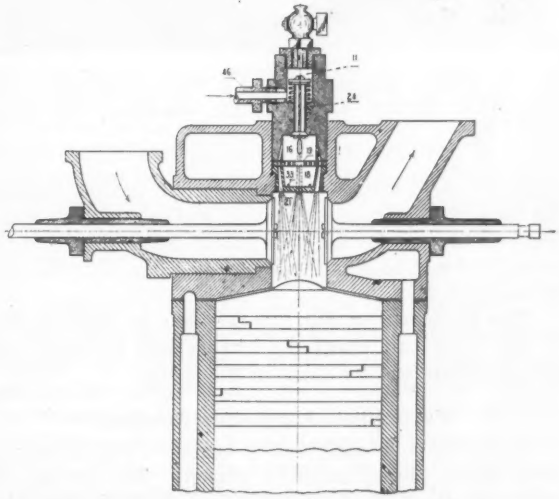


FIG. 7. SHOWS ARRANGEMENT OF INTAKE AND EXHAUST VALVES AND SLOPE OF PISTON

small seems to assist greatly in preventing combustion of the gas in the secondary chamber. The flow of gas from the chamber 18 is automatically controlled by the forward movement of the piston 37, viz.: As combustion of the gas in the combustion chamber 22 proceeds, and as the piston moves forward, the pressure will fall, thereby allowing rich gas to escape from the chamber 18 into the combustion chamber 22; this immediately burns and a reasonably slow feeding and burning of the gas goes on throughout the combustion period, or early part of the expansion stroke of the engine.

Another important feature is that the total area of the holes 20 must be greater than the total area of the holes 33 and 34. It is preferable to make this ratio about 6 to 1,

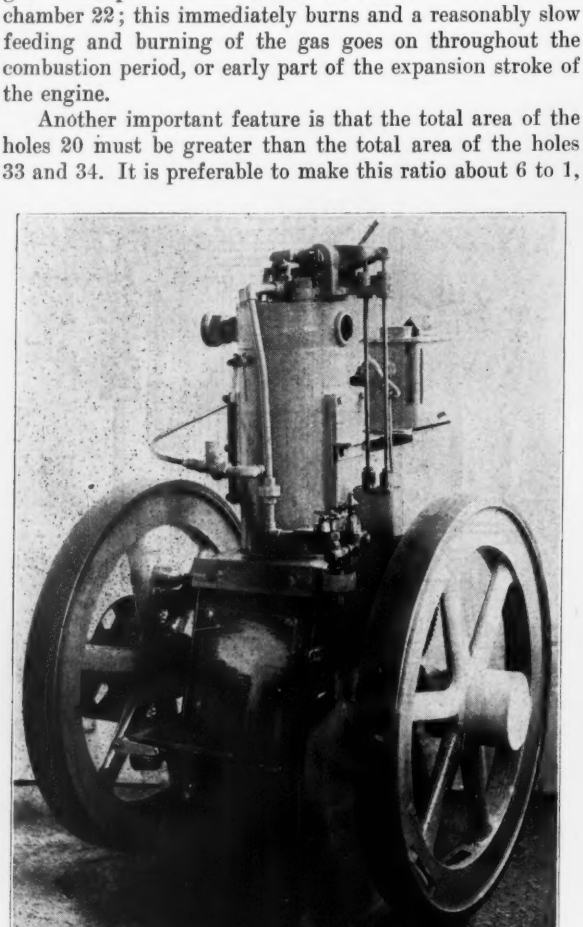


FIG. 8. SMALL VERTICAL ENGINE WITH GOVERNOR CONNECTED BY LEVERS TO ECCENTRIC SEGMENT FOR CLOSE REGULATION

otherwise there will be little air current passing through the holes 20 to atomize the fuel oil, and to carry it into the chamber 18; also for the same reason the total area of the holes 21 should be considerably greater than the total area of the holes 20.

The upper part of Fig. 7 is the same as shown in Fig. 1; the lower half shows the arrangement of intake and exhaust valves and the shape of the piston.

Tests Show Excellent Economy

Tests run on a small vertical engine of 4½ in. bore by 7 in. stroke, showed excellent economy. With 34 deg. Bé fuel oil, the fuel consumption was 0.475 lb. per b.hp. This engine is illustrated by Fig. 8. It runs at 800 r.p.m. and develops 9 b.hp. Since this engine gave such satisfactory performance it was decided to try the same design of fuel valve and precombustion chamber with a larger engine. Accordingly a 40-hp. stationary engine using producer gas was chosen. It was of the horizontal type with a 12-in. bore by 18-in. stroke. Since the old cylinder and cylinder head had to be replaced, a new cylinder with a bore of 9½ in. and the same 18 in. stroke, was used.

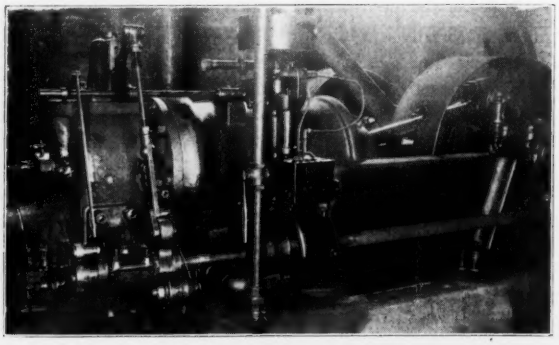


FIG. 9. 40-HP. GAS ENGINE CONVERTED TO OIL BY USE OF NEW VALVE

This converted engine is shown in Fig. 9. It has been giving exceptionally good results and is now running 10 hr. a day with a heavy load and using only from 6 to 7 gal. fuel oil during this period.

Bureau of Mines Investigates Refractories

IN MAY, 1924, a movement was started whereby the U. S. Bureau of Mines and 17 public utility and holding companies entered into a co-operative agreement to investigate conditions in boiler furnaces affecting the life of refractory materials.

It is generally conceded that the heat resisting qualities of refractories have not kept pace with the latest combustion practice and the high temperatures demanded and that improvements in fire-brick and tile are necessary.

Numbered among those co-operating with the Bureau of Mines are most of the larger power companies of the East and Middle West such as the New York Edison Co., Boston Edison Co., Public Service of N. J., Narragansett Light and Power, Detroit-Edison Co., Commonwealth Edison Co. of Chicago, and holding companies such as Stone and Webster, Inc., and the Henry L. Doherty Co.

It is planned to investigate furnace conditions with powdered coal, under-feed and chain grate stokers, and with oil firing. Some information has been obtained with powdered coal firing at the Sherman Creek Station in New York and at the present time work is being done at the Fiske St. Station in Chicago with chain grate stoker firing.

By means of thermo-couples embedded in the brick work, temperatures of the side walls, bridge wall, and ignition arch are carefully measured. Furnace drafts and the temperature of the gas next to the refractories is also noted. Samples of the gas are taken with water-cooled samplers.

In connection with the work in Chicago, the University of Illinois is also co-operating for the purpose of a study of the slagging and clinkering properties of the ash of Illinois coals.

Diesel Municipal Plant Shows Profits

OLD STEAM OPERATED UNITS AND GAS FIRED BOILERS DISCARDED WHEN HIGH PRICE AND SHORTAGE OF FUEL BECAME SERIOUS PROBLEMS

NEODESHA, A CITY in southern Kansas with a population of 4500, has for many years maintained its public utilities. Like other municipalities, the power plant is the outgrowth of the water system which had its beginning with a small steam pumping station purchased from a local oil refinery. The demand for electric service later arose and it was decided to install additional boilers and a 125-kw. generator driven by a high-speed, four-valve engine. The load gradually increased until it became necessary to install more generating capacity. The boiler plant was enlarged and a simple Corliss engine installed direct connected to a 250-kw. generator. At the time of installation, these units were as efficient and as suitable for the requirements as could be obtained, in fact there were no power units that were considered more serviceable for small plants of this kind.

During the last few years that the steam plant was in operation it was common knowledge to every Neodeshan, than the plant was being operated for service and not for profit. Even though every effort was made to give profitable service, the inefficiency of the existing equipment precluded the attainment of the desired results. By comparing the cost at which power was being produced with that being obtained in modern installations, it was evident that some decided action must be taken if the plant was to serve as a municipal asset.

It was also evident that the natural gas supply available from boiler fuel was diminishing; furthermore, the price had increased from 15 cents to 25 cents per 1000 cu. ft. This necessitated the choice of a more efficient form of power. Three types of units were considered, steam turbines, Uniflow engines and Diesel engines; due, however, to a constantly increasing cost of fuel and an insufficient supply of suitable condensing water, which would seriously affect the efficiency of the turbine during the summer months, little consideration was actually given to this type of unit.

Units ultimately decided upon were two Nordberg Mfg. Co. Diesel engines, each rated at 550 hp. at 225 r.p.m. Each engine is direct connected to a General Electric Co. alternator which is rated at 375 kw., 80 per cent power factor and 2300 v. Two exciters were provided, one for each unit. They are driven from the main shafts by means of Link-Belt Co. chain drives. The switchboard, made by the Westinghouse Electric & Mfg. Co., is provided with a tie-in panel with the industrial plant of the Standard Oil Co. Thus power can be fed either way in the event of an emergency. In order to insure a supply of compressed air for starting the engines there has been installed a single-stage, vertical compressor which is connected, by means of a belt, to a kerosene engine. Although this unit has been in now for over 2 yr. it has not been necessary to use it.

FIG. 1. TWO DIESEL ENGINES HAVE TAKEN UP THE LOAD RELINQUISHED BY OLD STEAM PLANT

PIPE CONNECTS FUEL TANKS WITH REFINERY

Fuel oil is stored in two tanks located outside of the building. One of these is of 3000 gal. capacity and is used for the storage of light oil for starting the engines. The second tank has a capacity of 10,000 gal. for the storage of heavy oil which is used during the regular runs of the engines. Due to the favorable location of this plant with respect to the oil refinery, these tanks are connected directly to the refinery by pipe lines. Rotary pumps draw the fuel oil from these tanks and discharge it into over-

head tanks in the engine room. The oil then flows by gravity to the fuel pumps on the engines.

Lubricating oil is pumped to overhead tanks from which it flows by gravity to the engines. The oil is drained from the crank case to a filter. An interesting feature of this installation is that the exhaust pipes are water jacketed and by throttling down on the water supplied to one exhaust pipe the water will reach a temperature of about 140 deg. F. It is then used to heat the oil in the filter. Further purification of the oil is effected by running all of the drainage through a De Laval separator. This is done three days out of each week.

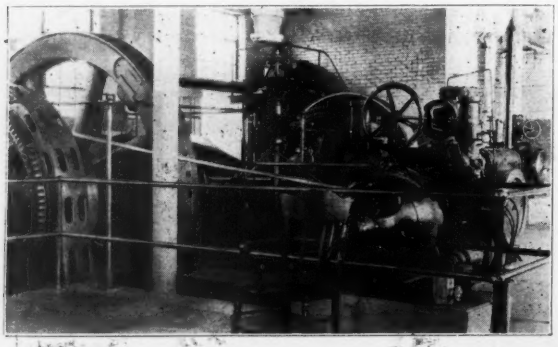


FIG. 2. THESE ENGINES WERE PART OF THE OLD STEAM PLANT

Outside of the building is an exhaust pit. It is located below the grade level and is made of concrete, its dimensions being 12 by 16 by 10 ft. It is partitioned through the center so that each engine exhausts into a separate compartment and each compartment is vented to the atmosphere.

Substantial Savings Made

Comparison of costs taken from the records of the steam plant for 10 mo. of 1922 with a corresponding period in 1923 for the Diesel plant shows results that are decidedly in favor of the latter. The savings for 10 mo. operation amounted to $18,624.27, which is 56.8 per cent of the cost for a similar period of operation with steam. In making this comparison it must be borne in mind that the output in 1923 increased 422,810 kw-hr. or 59.6 per cent. The correct cost comparison should, therefore, be made on a kilowatt-hour basis, which shows a percentage saving of 73.1 per cent in favor of the Diesel. These figures do not take into consideration the 16 per cent increase in amount of water pumped by the Diesel plant.

Tabulating the cost of fuel, labor, lubricants, supplies and maintenance, it has been shown that for the periods mentioned above the cost per kilowatt-hour generated by steam was 4.69 cents, whereas the corresponding cost of generation by the Diesel engines was 1.26 cents. The total cost of the plant was $153,600.

At the present time the night load is on a good basis as far as the load factor is concerned. The day load, however, is light. A high line is now being constructed which when completed and in service will, with the present day load, allow one unit to be operated at capacity. This will improve greatly the 24-hr. load factor.

City water is obtained from the Fall River by means of low-head pumps located at the river bank. These pumps discharge into a reservoir or settling basin. Sulphate of iron, lime and aluminum sulphate are added to the water just ahead of the reservoir from which the water flows by gravity through sand filters to a clear well. High-head pumps draw water from the clear well and discharge it into an overhead tank which is of sufficient capacity to serve the city for about 4 hr. during the summer months. Chlorine is added to the water just ahead of the high pressure pumps.

The river has been dammed so that an adequate supply of water is assured. Water used for condensing and cooling purposes by the oil refinery is discharged into the river just above the intake to the pump house. This tempering of the water is not objectionable during the summer and in winter it keeps the river from freezing over, thus preventing ice troubles at the pump house. Water for cooling the cylinder jackets is tapped from the city mains, thus the use of treated water eliminates troubles which would result from the formation of scale in the cylinder jackets.

The two low-pressure pumps are single-stage centrifugals, each motor driven and rated at 700 g.p.m. One of the high-pressure pumps is a single-stage unit, motor driven and rated at 500 g.p.m. and 175 ft. head. The other unit is a two-stage centrifugal, motor driven and rated at 750 g.p.m. All of these pumps were made by

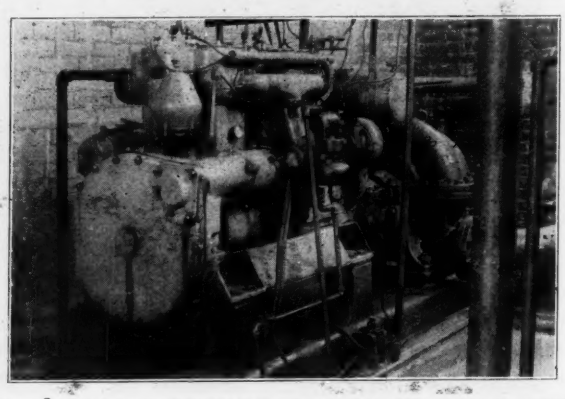


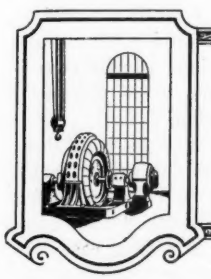
FIG. 3. FIRE PROTECTION IS PROVIDED FOR BY GASOLENE ENGINE DRIVEN PUMPS

the American Well Works and the motors were furnished by the General Electric Co. For fire service there have been provided two three-stage Lecourtenay centrifugal pumps, each direct connected to a Sterling gasoline engine. The pumps are each rated at 700 g.p.m., 231 ft. total head at 1080 r.p.m. Each engine is rated at 100 hp.

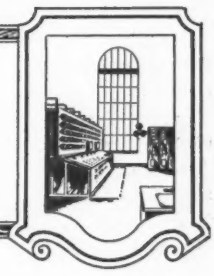
The plant is under the supervision of J. A. Boggs, who has charge of the generating equipment, distribution lines and water system. Under him are three engineers, working in shifts of 8 hr. each, one pump man and a relief man, the latter relieving the others one day each week.

Comparative costs of ice cooling and electrical-operated refrigerators have been estimated by the National Electric Light Ass'n on a basis of 2.62 kw-hr. a day at 5.3 cents per kw-hr. and 40 lb. of ice at 60 cents per 100 lb. Ice will cost $86.40 for a year and electric current $50.67 a year. Cost of the electric refrigerating unit is about $250.

Don't expect a Venturi meter to register accurately when the throat of the tube is covered with scale.



ELECTRICAL MACHINERY FOR LIGHT AND POWER



Small or Large Motors for Industrial Plants

SOME ASPECTS OF THE PROBLEM REGARDING THE INSTALLATION OF GROUP DRIVE OR INDIVIDUAL MOTORS IN INDUSTRIAL PLANTS. BY MORGAN G. FARRELL*

ONE OF THE MOST difficult questions confronting the plant manager who contemplates electrifying his plant is when and where to use individual motors, group drive or room drive.

The answer involves a close study of the first cost of the installation, the operating efficiency and the average

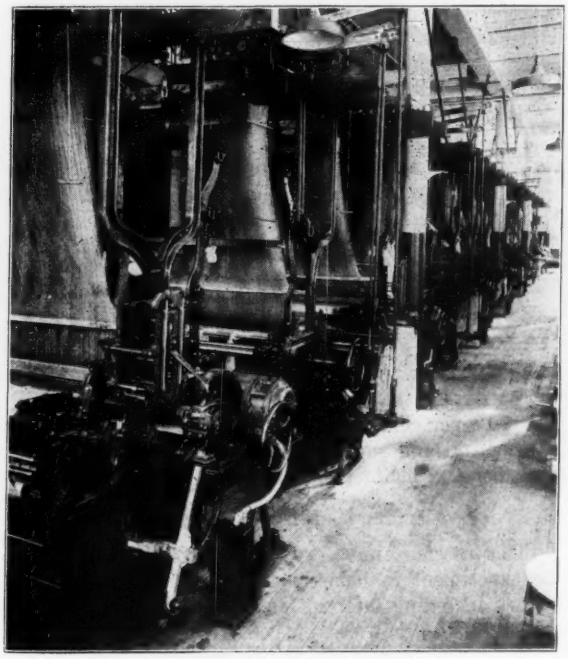


FIG. 1. VIEW IN LARGE TEXTILE MILL SHOWING USE OF INDIVIDUAL DRIVE MOTORS

actual load of each machine. A correct decision is especially necessary where power is purchased; for a large number of motors running light may have a very serious bearing upon the power factor of the plant as a whole.

Consider a cotton-mill, for example. Here is a typical table of machines in each department and the motor horsepower required to *start* them.

With a direct mechanical drive of the old type, such a mill would employ two Corliss engines of 1200 hp. each, so that the total mechanical power supplied would be 2400 hp. This would have to take care of 4340 connected hp. plus about 25 per cent friction losses or 5425 hp. in all. That is, the load factor would be 44.2.

*Vice President, Frank Hill Smith, Inc., New York, N. Y.

Number	Class of machine	Hp. of each	Total hp.
8	Breaker pickers	10	80
40	Cards	5	200
80	Drawing heads	3	240
30	Roving frames	10	300
60	Intermediate frames	10	600
60	Spinning frames	10	600
40	Warpers	3	120
5	Slashers	10	50
10	Twisters, etc.	5	50
600	Looms	3	1800
	Misc. motors		300

933 Machines at 4340 hp.

Horsepower given for each machine is the maker's rating. The actual power requirement may be and usually is considerably less. Spinning frames, for example can be driven easily by individual 7½ hp. motors provided they do not exceed 240 spindles. The average cotton mill spinning frame has 360 spindles and 10 hp. motors, while mule spinning frames in mills weaving finer goods run as high as 1800 spindles requiring at least 30 hp. The outlay involved in electrifying a mill of this class is a heavy one in any case so that the difference between the first cost of individual or group electrification will serve as a general criterion for smaller plants in other industries.

Let us see what it would cost to equip each machine in the cotton mill with an individual motor of the required hp. at 220-v. a.c.

163	10 hp. motors, installed	$ 40,750.00
50	5 hp. motors, installed	10,000.00
720	3 hp. motors, installed	79,200.00
20	15 hp. motors, installed	6,400.00
	Total	$136,350.00

Which accounts for the motors and starting devices, set and wired up. Add for the distribution system, switchboard and accessories, $30,000, and the total cost is about $166,000 which is a rather stiff price even for a cotton mill representing a total investment in plant and buildings of about $2,500,000.

Now, the usual practice in cotton mills where group drive has been adopted, is to use from one to three large motors for each room—motors ranging from 50 to 150 hp. each. Let us see here how the installation cost would compare with the individual drive, assuming the load factor to be 44.2 (including a slight overload in a few cases):

Machine	Connected hp.	No. Motors	hp.		Installed Cost
Breaker pickers ..	80	1 @	40 =	40	$ 800.00
Cards	200	3 @	30 =	90	1,800.00
Drawing frames ..	240	3 @	35 =	105	1,650.00
Roving frames ...	300	4 @	30 =	120	2,400.00
Intermed. frames .	600	5 @	50 =	250	3,500.00
Spinning frames ..	600	5 @	50 =	250	3,500.00
Warpers	120	2 @	50 =	100	1,400.00
Slashers	50	1 @	50 =	50	700.00
Twisters	50	1 @	50 =	50	700.00
Looms 1800		18 @	100 =	1800	21,600.00
Miscel.	300	10 @	30 =	300	6,000.00
	4340	53		3155	$44,000.00

Less than one-third the installation cost of individual drive motors.

The cotton-mill has been selected as an illustration because it represents the average condition in almost any

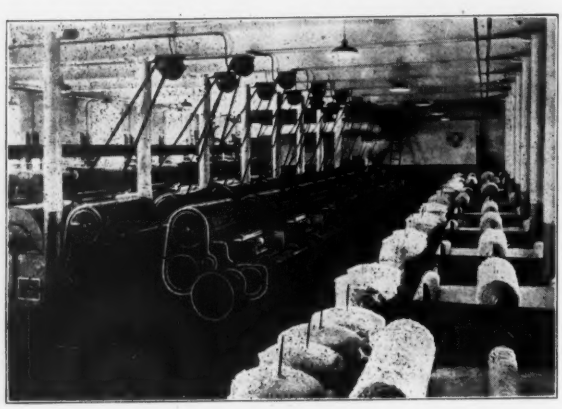


FIG. 2. FIVE AND 7½-HP., 1800-R.P.M. PICKER MOTORS, DRIVING TWO HEATER BREAKER PICKERS IN A TEXTILE MILL

factory employed in quantity production. Moreover the standardization of both their mechanical and electrical equipment permits a fairer comparison between the two as well as between the group, and single drive systems.

Broadly the decisive factor is the relative cost of power. A mill such as that previously described will have a power bill of about $1000 a day if it makes its own current—$300,000 a year.

Whether the power is purchased or generated at the plant, the reduction in power costs by electrification is none the less positive. Purchased power meant the abandonment, in the case of the mill cited as an example, of a battery of twenty 150-hp. return tubular boilers with the boiler house, stacks, economizer and auxiliaries, representing in all an investment of $120,000 and of 2400 engine horsepower with the engine-room, piping, headshafts, drive and housing, which accounted for another $120,000. So that including all equipment discarded, about a quarter million dollars' worth was scrapped. In book-values the loss was much less serious. For it has been the historical custom in the cotton mill section to charge off a heavy depreciation on both buildings and equipment. In fact the advent of the excess profits tax law found the value of the fixed assets of the mills carried on their books at an uncomfortably low figure. However, at the time of the electrification the power plant of the mill in question was 20 yr. old. At the very moderate depreciation rate of 3 per cent a year (too little, considering obsolescence) the accrued depreciation would have been 60 per cent and the residual valuation, 40 per cent or about $100,000. This amount of course would have to be charged against the cost of electrification.

It is plain therefore that an industry in the tight financial position of the cotton mills after the armistice had very little choice between investing in electrical equipment $266,000 for individual drive or $144,000 for group drive. And it is equally obvious that in neither case could they afford the initial investment in new prime-movers and generators to make their own power. For this would have involved not only the installed cost of the new units, but the removal of the old ones as well—and for these there was no market value whatever. Their scrap value would hardly have paid for their removal.

One of the best managed mills of the Massachusetts group attempted to do just that. The treasurer (who in cotton mills is the sales manager, purchasing agent and works manager rolled into one, and who usually dies of worry in his latter forties) electrified the mill. During the process he dickered with the local power company over the current charge. They asked what amounted to 3.25 cents per kw-hr. He insisted that he could build his own plant and supply current at less than three cents and that if they could not meet his figure he would go ahead and buy his generators. He did, with this result:

Motorizing the plant, 5000 connected hp.	$120,000.00
New engines, L. P. turbine, switchboard, piping and auxiliaries.....	180,000.00
Scrapping and removing old engines, foundations, etc., including residual values	60,000.00
New engine room and alterations to old	65,000.00
Total,	$425,000.00
The fixed and operating charges were:	
Interest, depreciation and taxes, about 12 per cent.....	$ 51,000.00
Fuel, oil and supplies.....	225,000.00
Labor and maintenance.....	30,000.00
	$306,000.00

The metered annual kw-hr. totaled 7,500,000, so that the experiment in home-made power cost 4.08 cents per kw-hr., including interest, etc., on the cost of motorizing.

Eventually the treasurer came to terms with the power company and now a beautiful, maroon-colored 3500-hp. engine with its complement of boilers stand idle, awaiting the contingency of a breakdown in the public supply.

We have dwelt upon the question of made or purchased power in connection with the choice between individual and group electric drives because the two are usually inseparable. No one wants to scrap a perfectly good steam plant if there is any way of converting it into an electric plant.

The writer has made many such comparisons of cost and has yet to see a plant in which it is cheaper to generate than to purchase power, except in cases where exhaust steam is extensively used for processing. In the latter case there is a heat balance in favor of made power. Such plants as textile mills with dye and wash houses or chemical plants in which there is a large and constant demand for hot water, can undoubtedly use their own power to advantage.

But for the average plant where the mechanical demand is far in excess of that for exhaust steam for heating purposes, there is hardly a question that purchased power is cheaper than home-generated power.

To return to the problem of small or large motors: the General Electric Co. has recognized that the group drive is superior in first cost and operating economy in the case at least of machines of such uniform loading and constant production as spinning frames. They have developed a special motor with an extra heavy shaft extended on both ends, with two pulleys on each to drive four such frames. These motors rate from 15 hp. up. If individual motors were used on those same frames each motor would rate from 7.5 to 10 hp. Thus one

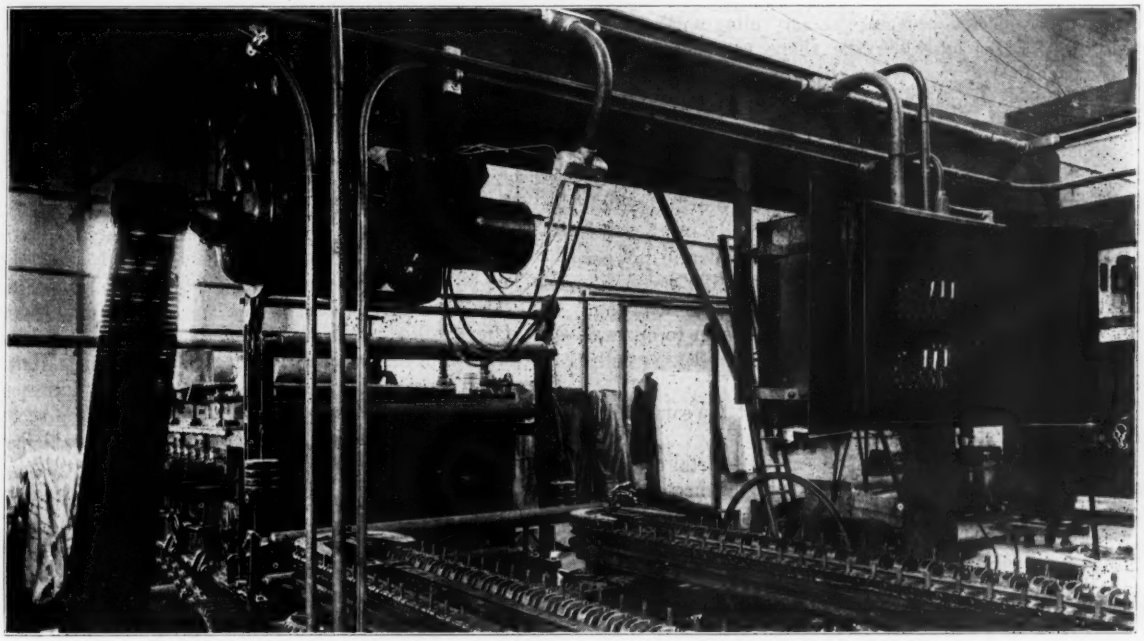


FIG. 3. AN ADJUSTABLE SPEED A.C. MOTOR DRIVING MERCERIZING RANGES IN TANDEM. THIS SHOWS MAIN MOTOR OF ONE RANGE WITH PILOT MOTOR FOR SHIFTING BRUSHES

15-hp. four-frame motor, wired up, would cost about $400, while four 7.5-hp. motors wired up would cost nearly $800.

We have been speaking thus far of induction motors of the squirrel-cage type. In the direct-current type of motor such as would ordinarily be used on machine-tools, in a metal-working shop, the difference is even more considerable. For, not only is the differential increase in cost per horsepower appreciably greater in the case of direct current motors, but the expense of the motors plus installation rises rapidly as the voltage decreases.

The writer well recalls a memorable example of injudicious selection of motor voltage during the late war. A regiment had been organized in Washington as a shop and supply unit. Their duties were outlined by the chief of engineers and their technical head was given free rein to select such equipment as would best fit them to function accordingly in the field. Doubtless there were many brain-racking sessions of the few field officers upon whom devolved the responsibility of determining the organization of an engineering unit whose like had never before been seen in the history of war, and the purpose of which was more or less nebulous. At any rate they did the best they could. Plans were made, tools bought, material ordered. In due course, other officers, supposedly mechanical engineers, were sent to join the regiment, the rank and file was assembled (also supposedly skilled mechanics) and the regiment was ordered overseas.

Then the situation which confronted their field-shop officer was this: He had to establish shops to make anything from minor repairs on motor trucks of all makes to building complete structural and mechanical units. The machine tools available in those early days had been of English make, diverted from their original consignees, the moribund Russian government, and were without visible means of power. So there was nothing to do but to set the tools up and drive them through line shafting operated by gasoline engines. Later standard American tools began coming through.

One machine shop had the following tools set up and in operation:

4	Turret lathes	@ 5	hp. =	20
10	Lathes, 8 in. to 24 in.	@ 4	hp. =	40
3	Millers	@ 6	hp. =	18
2	Shapers	@ 6	hp. =	12
6	Drill presses and multiple drills	@ 3	hp. =	18
2	Horizontal borers	@ 7½	hp. =	15
1	Vertical boring mill	@ 10	hp. =	10
1	Set tool room tools	@ 15	hp. =	15
2	Vertical millers	@ 5	hp. =	10
6	Hack saws	@ 1	hp. =	6
2	36 in. x 8 ft. planers	@ 15	hp. =	30
			Total,	194 hp.

or with minor auxiliaries, 200 hp., plus 30 per cent for frictional losses = 260 hp. Yet this load was carried easily by a 120-hp. gasoline engine.

In due time the equipment actually ordered for the use of the regiment arrived. The machine tools were of

the finest, each packed with its full complement of gears, cutters, tool carriers, etc., and each well protected by cosmoline against the long sea voyage. All this was in contrast to the English tools which arrived without so much as a countershaft, and rusted and pitted beyond all accurate use.

But the motors! The harassed shop officer took one look at the school of whales intended to work his tools and quit for the day. Later in the evening he was discovered in a state of deep gloom and a cafe.

The 5-hp. motors were as big as the usual 15 or 20-hp. alternating current squirrel cage type and the others in proportion. The lightest fully equipped weighed 375 lb. And the shops were supposed to be movable on 24 hr. notice. The fact of the matter was that 110-v. d.c. motors had been selected because "higher voltages might be dangerous." Later on when the shops moved up front they were bombed during the night raids which proved to be a trifle more dangerous to the operators than 110-v. circuits. The shop did good service during the rest of the campaign, but the motors were left behind in storage.

In a later article the question of high-voltage motors will be taken up. The point here is that the individual low voltage direct current motors were totally impractical both from the standpoint of first cost, weight and power. For the only prime movers provided were the beautiful four-cylinder General Electric Co. lighting units of 25 hp. each, weighing 800 lb. And it took six of them to operate the shop which a 1200-lb. gas engine had successfully driven.

Of course this is an aggravated case, but the same principle applies to a stationary plant.

Load factor in any machine, wood, sheet-metal or forge shop is seldom more than 1/3 the total connected load. The makers specify the horsepower of each machine and they play safe. A lathe for which a 7½-hp. motor is specified may require that much to take the largest cut on the maximum piece, but under ordinary working conditions it may go on for its entire lifetime at an average consumption of two horsepower. Just as a freight locomotive may labor to start a 40-car train, but once it is started it can bowl along at 30 miles an hour.

As an example, the writer once laid out a woodworking shop on the group-drive principle. In one group were a four-side planer, a two-side planer, a rip-saw and a circular saw. The makers' requirements called for 35 + 25 + 15 + 10 hp. = 85 hp. On the principle that they would never operate under maximum load at the same time, a 50-hp., 220 v. a.c. motor was assigned to the group. The large planer was started up alone; 2 by 12-in. hard pine planks were fed to it at 200 ft. per min.; as the fourth plank was passing through, the overload relay kicked out and the motor stopped.

"How come?" said I to the planer foreman, "I thought you said 35 hp. would carry you."

"It should," said he, "your motor is weak in the back."

"My motor says 50 hp. If it stops you're using more than that."

"Can't be—I've installed 70 of these here machines and"—etc., etc.

So I slowed down the relay to take an overload of 50 per cent, meanwhile sending for a wattmeter, voltmeter and ammeter. Still the relay kicked out. I slowed it down some more and climbed up on the motor platform. The motor was warm, sure enough, but it had buckled down to work and the hard pine planings flew. When the instruments arrived, I shut down to connect them in the circuit. Then off we went again. A few readings and a brief calculation.

"Your 35-hp. planer is drawing just 88 hp. at a power factor of 75 per cent."

And it was. New and stiff and probably badly adjusted, it took all of that. Later on when it was limbered up, it went along with the rest of the machines in the group without demanding any extra work of the 50-hp. motor.

Now this applies with equal force to any kind of machine drive. If you gage the size of the motor by the power required to start a newly set up stiff machine you will be wrong by at least 50 per cent. And if you put an individual drive on any machine, the motor, which must start the mechanism from rest will have some three times the power necessary to keep going after it is once started.

There is the inertia of all the moving parts to overcome, the initial friction, and in the case of a.c. motors, the starting current of the motor itself—4 to 10 times the running current.

Obviously the group or room drive helps eliminate these. Take a room with 30 machines starting under load at 10 hp. each. It is extremely unlikely that they will all be started at once, even in the morning. There is always some adjustment of the work being done which will spread the starting time over 10 min. or so. If that room is equipped with one 100-hp. motor which is started when the whistle blows, it will be running at full speed before the first machine is thrown in. When the second and third machines are thrown in the first will have reached running speed, so that the motor load will never be much more than that required to keep the machines running. That seems to be only common sense.

There is little argument here in favor of the individual drive except in the case of very large machines intermittently operated, such as cranes, presses, elevators, large planers, etc. To take care of them, a group drive motor would have to be so big that under average running conditions it would be operating at a fractional load with consequent power factor loss.

The question of large or small motors, in shops of this kind, resolves itself into a determination of the size of the group to be operated by a single motor. And this is decided by the continuity of operation of the machines in the group. The load in a weave-shed, for instance, is fairly constant. Once the looms are started they keep on going, except when a warp-thread breaks or a run is finished. One loom of average size is supposed to require a 3-hp. motor. It is not unusual to have 2000 looms in a large shed. That would mean 6000 hp. of motors. As a matter of actual measurement those looms on the average require only ½ to 1½ hp. under running conditions or 1000 to 3000 hp. The only safe way to decide the size of group drive motors is to select, say, a 100 hp. and try it out, adding looms until it is fully loaded.

Here the operation is continuous. In a wood-shop, for example, machine work is more intermittent. Consider the case of a trim mill working on contract orders. The rough lumber is brought to the cutoff saws and cut to length. Then the saws are through for awhile. The boards are ripped and planed, passed on to the molders, mortise and tenon machines, dado, sanders and so on. It is a safe statement that no machine is in active operation more than one-fourth the time.

If it is feasible, a single motor should drive a group of machines which come into action simultaneously. The object is to load the motors as fully as possible while they are running and it is more economical than to have them run light.

On the other hand, individual motors will pay when mounted on tools which start without load and which operate continuously on the same kind of parts, as in any quantity production process. Tools which fall under this class are: boring mills, planers, punch presses and large lathes, millers, shapers, etc. Drill presses, and small tools generally, are driven with greater economy by group motors.

Again there are certain conditions under which direct-connected individual motors are preferable, even when applied to machines which start fully loaded. In coating processes, for instance, the room atmosphere is charged with inflammable fumes which may be ignited by static discharges from belting in spite of all precautions. The same is true of starch and flour mills, celluloid and cellulose plants and the like.

Sometimes the nature of the goods fabricated makes it desirable to dispense with overhead shafting on account of the danger of oil drip or the structural vibration set up. Manufacturers of broad silks and velvets prefer to use individual motors because they have experienced the damage caused by oil splashed on the goods or dust and lint shaken down from the ceiling by the vibration of shafting. They find it more satisfactory to use single motors than to provide a basement below and drive up through the floor.

Another place for the individual drive is the sewing-machine tables in clothing, shoe and straw-hat plants. Each table has about twenty machines operated by a motor below. An additional advantage is that the tables can be set along or across the room or in rooms in which it would be impractical to install overhead shafting on account of low headroom, trussed roof construction and so on.

With these and similar exceptions noted, the case for the large or group motor may be summed up:

1. Their first cost is lower,
2. They maintain a higher power factor,
3. Their upkeep is less,
4. Their power reserve is greater,
5. They are more flexible.

New Two- to Six-Phase Transformer Connection

A New Transformer Connection of 100 Per Cent Apparatus Economy. A Comparison of Its Merits With Those of the Scott and Woodbridge Connections

AT THE RECENT annual convention of the American Institute of Electrical Engineers at Saratoga Springs, N. Y., A. Boyajian of the General Electric Co., described a new transformer connection which he said had a 100 per cent apparatus economy when transforming from two-phase to six-phase.

By apparatus economy is meant the ratio of the single-phase transformer kv.a. rating of the device to its kv.a. rating as a phase transformer. This ratio is sometimes called "internal power factor." This latter term, however, is not so good, because of the fact that, although at unity power factor loads the value of the internal power factor is identically the same as the apparatus economy, yet the internal power factor varies with the load power factor, while the apparatus economy is independent of the load power factor.

Description of the Connection

Figure 1 shows the connection diagrammatically.

The core and flux are two-phase, so that two single-phase cores or one two-phase core would be necessary and sufficient.

Considering the windings, two windings are needed on the two-phase side, one for each phase. They may be interconnected (as T, L, or diagrammatically), or they may be entirely independent. This freedom is advantageous in being adaptable to any two-phase system.

On the six-phase side, we have a rectangle, B C E F, crossed by the line A D. The voltages of the various parts are shown in the illustration.

It may be noted that the six-phase side may also be considered a diametric three-phase system, since any diametric three-phase device may be operated from it.

The common connection for two-phase to six-phase transformation is the so-called double-T or double Scott connection shown in Fig. 2. While structurally there is a great deal of resemblance between this and the new connection, what little difference there is accounts for the difference in the apparatus economy of the two connections. The maximum apparatus economy which the

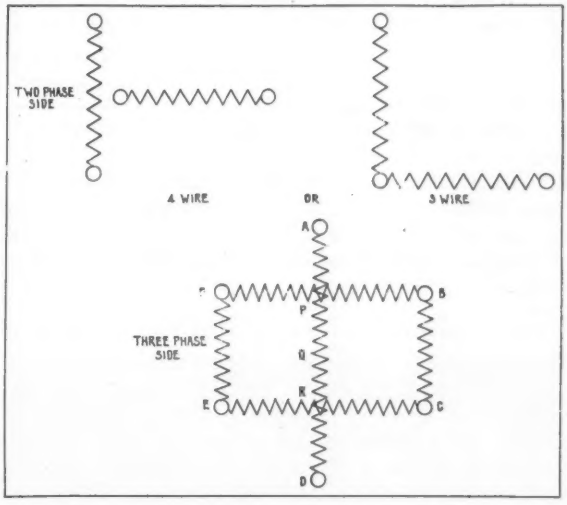


FIG. 1. TWO-PHASE TO DIAMETRIC THREE-PHASE OR SIX-PHASE TRANSFORMERS

Three-phase side:
Voltages: AD — BE — CF — 100 per cent.
AP — PQ — QR — RD — 25 per cent.
BC — PR — FE — 50 per cent.
BP — PF — CR — RE — 43.3 per cent.
Current in lines — 100 per cent.
Current in AP — PQ — QR — RD — 100 per cent.
Current in BC — FE — 50 per cent.
Current in BP — PF — CR — RE — 86.6 per cent.

Scott connection is capable of is 96.6 per cent (using non-interchangeable units and properly interlaced three-phase main windings) as against the 100 per cent apparatus economy of the new connection. Besides this difference in economy, the new connection is free from the trouble

of the interlacing requirement for the two halves of the main winding in the Scott connection. This advantage is more appreciated if it is considered that six-phase circuits are usually of low voltage and high current, and proper interlacing of the two halves of the main is not a simple matter.

It will be observed that the Scott connection can be converted into the new connection by redistributing the two teaser windings around the two main windings in accordance with Fig. 1.

A disadvantage of the new connection in comparison with the Scott connection is that the former is not adaptable for the use of interchangeable units. If a spare is needed, it must be a complete polyphase unit, while in Scott connection a single-phase spare may be sufficient. In this interchangeable scheme, however, the apparatus economy of the Scott connection is at best only 93.8 per cent.

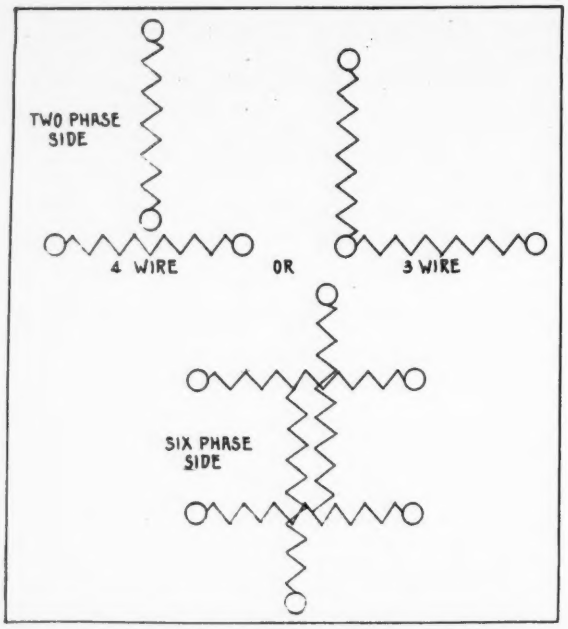


FIG. 2. DOUBLE-T OR DOUBLE-SCOTT CONNECTION

New Connection Compared with the Woodbridge Connection

The Woodbridge connection is a 100 per cent economy connection shown in Fig. 3. Originally this connection was intended for two-phase to three-phase transformation, but its applicability to two-phase to six-phase transformation is obvious. The Woodbridge connection, although of high economy, is seldom used on account of three limitations: (1) being a 4-wire two-phase connection, it is not adaptable to a 3-wire two-phase circuit; (2) the two-phase side is unsuited for taps; and (3) it is as complicated for two-phase to three-phase service as for two-phase to six-phase service, while in the matter of simplicity, adaptability and convenience for two-phase, three-phase service the Scott connection is far ahead of any of the other many connections so far invented. The new connection here described is not adaptable at all to three-wire three-phase service.

For six-phase service, the Scott, the Woodbridge and the new connections are of the same order of complexity in the matter of windings, but the latter two do not need the particular interlacing required by the Scott connection. Since taps are or would be placed on the two-phase side, in this service the Woodbridge connection is at a serious disadvantage.

In this comparison a point of great theoretical interest is that both of the two 100 per cent economy connections are "diametric" in their derived phases, but free and flexible in their original. The Woodbridge connection uses three-phase flux, and is flexible in its three-phase side, its original side, being capable of either diametric or mesh connection. However, on its derived side, viz., the two-phase side, the connection is entirely limited to four-wire diametric connection. The new connection here described utilizes two-phase flux and this being its original phase, it is capable of any two-phase connection; however, on its derived side, the three-phase side, it has to be diametric, that is, six-wire three-phase, and is therefore not adaptable to ordinary three-wire three-phase circuits.

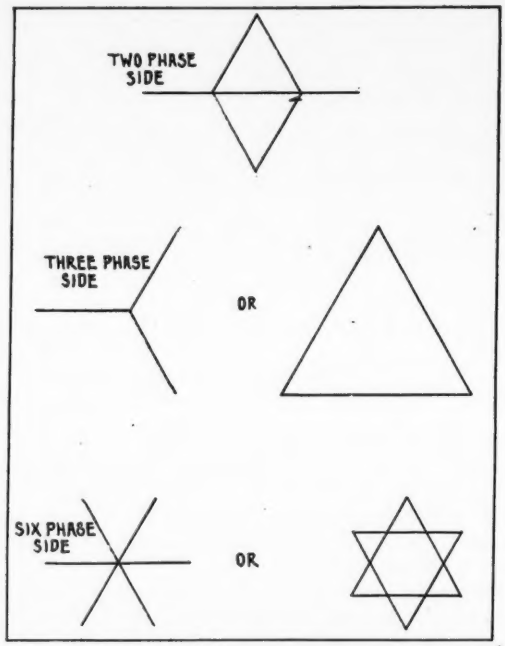
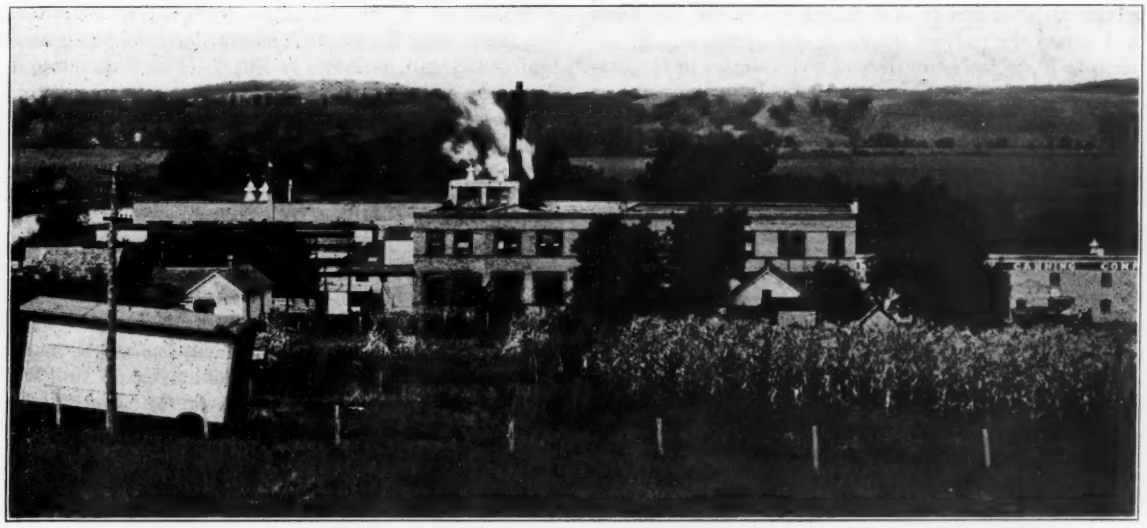


FIG. 3. THE WOODBRIDGE CONNECTION

Submarine cables are increasing in use so much that the problem of getting gutta percha for covering has been serious. The cost of this insulating covering has been more than all other items together, as gutta percha is the gum from a tree which grows in the far east and collecting has been done by cutting down large trees, each of which yields only a few pounds of the gum.

Investigation carried out by the Bureau of Standards on rubber and similar materials has shown that by proper compounding with other materials, a rubber insulation can be made which, in some respects, is superior to gutta percha. Many combinations were tried and it is probable that some compounds which were not found suited for cable insulation will be just what is needed for other uses.



Canning Company Makes Power Economically

PLANT OF MINNESOTA VALLEY CANNING CO. WAS DESIGNED TO BURN FUEL OIL AND TO SUPPLY PROCESS STEAM FROM EXHAUST OF NON-CONDENSING TURBINE. BY RALPH W. RICHARDSON

AS AN illustration of the way in which a small industrial power plant may be designed to operate economically and without excessive attention, the new plant of the Minnesota Valley Canning Co., at Le Sueur, Minn., possesses many features of interest.

This company has developed a large pea and corn packing industry on the banks of the Minnesota River, about 60 miles from the Twin Cities. Starting in a small way in 1903 with an output of 16 carloads, the business has grown steadily since its inception, its capacity in 1924 being 310 carloads. This plant produces only the highest grade of product and in order to do this it has been necessary, of course, to install the latest and finest type of machinery. In addition to this, the company has given such care and thought to the surroundings and design of the plant that the buildings are of unusually fine construction and are at all times scrupulously clean.

Early in 1923, it became evident that it was necessary to make provision for additional power and the writer was engaged to prepare a report and preliminary plans and specifications for a power plant suitable for their present and prospective needs. He early recognized the fact that an ordinary power plant for this duty would not meet the exacting requirements that existed, so the matter was given considerable thought and study, with the result that a power plant was designed and built with a number of unique features.

TURBINE EXHAUST IS USED FOR PROCESS WORK

Chief among these features was the installation of a steam turbine operating at a high back pressure and supplying exhaust steam for operating retorts for cooking. This enabled the company to produce its own electric power at a minimum cost. This is probably the first corn and pea canning factory in which exhaust steam has been used for process work. A second feature was the installation of an oil-burning boiler in the power plant in order to

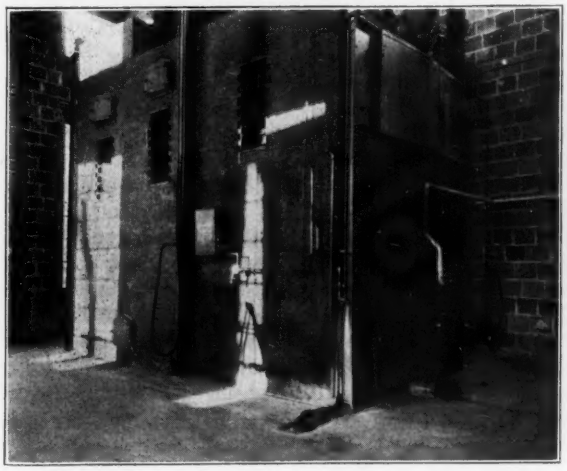


FIG. 1. PRESENT BOILER IS EQUIPPED WITH OIL BURNER, BALANCED DRAFT EQUIPMENT AND FLUE GAS TEMPERATURE RECORDER SHOWN ON REAR WALL

FIG. 2. 150-KV.A. TURBO-GENERATOR, MILL PUMPS, BOILER FEED PUMP ARE CONVENIENTLY ARRANGED IN LARGE, WELL-LIGHTED TURBINE ROOM

eliminate all dust and smoke. Third, the power plant was placed across the railway tracks in close proximity to the Minnesota River to insure thorough cleanliness in the canning factory. Sufficient space is available in the plant so that repairs and alterations may be made on any of the machinery with ease, and space has also been provided for future duplicate turbine and boiler units. Fourth, an interesting method of softening the water without the introduction of any chemicals was worked out and is in

FIG. 3. POWER PLANT BUILDING IS OF TILE CONSTRUCTION, WITH BRICK TRIM AND STEEL SASH

successful operation. Two artesian wells were sunk to provide the best possible water, not only for the canning process, but to insure an adequate supply of flowing water for the cooling of the product as it came from the retort room. The plant and canning factory are driven entirely by electric motors, including the triplex boiler feed pumps. Finally, automatic control was placed on steam lines and recording and integrating instruments on oil, steam and water lines, with a complete equipment of temperature indicating and recording apparatus, so that the plan might be operated not only at the highest point of economy but in such an intelligent manner that the management and the operators might know at all times just what they are accomplishing.

Little information was to be had when the writer was engaged for this work, as no indicating or recording instruments were in use, and it was necessary to estimate requirements throughout. The apparatus as installed, however, fits the conditions and is showing an appreciable saving in the cost of operation and freedom from loss of time or shut-downs.

Figures 4 and 5 show the general layout of the new plant, the building itself being illustrated in Fig. 3. This structure was built of Denison Load-bearing Tile, with trim of face brick and windows set in steel sash. Since the oil-burning equipment occupies little space, the boiler room is small and conveniently arranged, a place being provided for the second boiler which will be installed later. The turbine room is large and well-lighted and there is plenty of room around the various pieces of equipment. Piping has been simplified as much as possible; process steam and hot and cold water pipes, as well as the electrical leads, are all collected in a concrete-lined trench, as shown in Figs. 4 and 5.

Somewhat to one side of the room is placed the turbo-generator, with the motor-driven boiler feed pump near it against the wall, as shown in Fig. 2. This illustration also shows the arrangement of the three centrifugal pumps for hot and cold water service. Piping connections for these pumps are shown in Fig. 4. Figures 2 and 6 show the cover of the concrete-lined trench through which the turbine exhaust runs to the open feed water heater that serves also as a water softener.

Fuel Oil Burner Pumps and Tanks Arranged for Simplicity

At the time of building the power plant, the boiler unit shown in Fig. 1 was installed; another one will be installed in 1925. The present unit is a 209-hp. Union Iron Works horizontal, vertical baffle boiler, built for a working pressure of 175 lb., fired by means of an Enco oil burner, manufactured by the Engineer Co. of New York City, with balanced draft equipment furnished by the same concern. Owing to the fact that the boiler is operated only about 4 mo. each year and that oil fuel is used, no permanent flue blowers are installed. When the second boiler is installed it will be in an independent setting, with about 4 ft. between boilers.

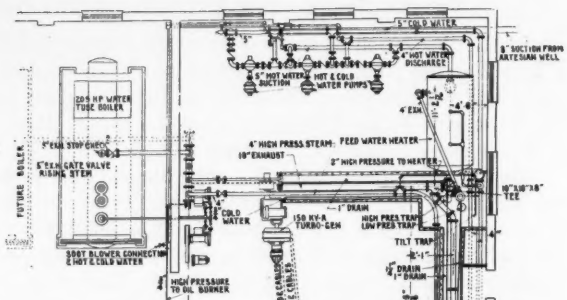


FIG. 4. PLAN OF BOILER AND TURBINE ROOMS SHOWING BOILER, TURBINE, PUMPS, FEED WATER HEATER AND PIPING

Fuel oil is stored in two 10,000-gal. tanks buried in the ground outside of the boiler room and at such an elevation that the oil will flow easily from the tank cars to these tanks and from the tanks to the oil pressure control pumps. The latter consist of two duplex steam pumps with a closed type of preheater.

These oil tanks are set upon three piers, the two front piers being closed in by means of concrete and brick, leaving a space under the front half of the tank approximately 6 ft. square by 18 in. deep. One end of this pit is slightly lower than the other so that the water will drain from it. Exhaust steam from the air compressor is admitted to this pit, together with the exhaust steam from the oil circulating pumps and serves to keep the oil at a temperature which facilitates its flow by gravity through the pipe connections.

Feed lines to these oil tanks run underground and underneath four railway tracks to the unloading switch track. Two independent lines were run, one to each tank, and midway between these lines was run a 1-in. high pres-

sure steam line with connections at the unloading end for connecting to the tank nozzles in the tank cars. They serve two purposes, one to heat up the oil in the tanks, the other to radiate sufficient heat to keep the pipes running back to the oil tanks at a moderate temperature. These lines were all enclosed in protective covering and covered with about 18 in. of soil.

Utilization of Turbine Exhaust Leads to Economy

Current is generated by a 150-kv.a., three-phase, 60-cycle, 220-v., Westinghouse alternating current generator driven through Westinghouse reduction gears by a double jet Westinghouse steam turbine, as shown in Fig. 2. This combination was selected due to the fact that higher economy could be obtained with a geared type turbine of this size, first cost and maintenance being considered and that the amount of steam available closely approximated the operating requirements of factory and water softener. The normal speed of the generator is 900 r.p.m. and that of the turbine 6000 r.p.m. This steam turbine was designed to operate at 165 lb. boiler pressure and guarantees were made on 20 lb. back pressure. Under actual operating conditions it was found that back pressure ranging from 15 to 24 lb. was desirable. This was controlled by means of a Cochrane

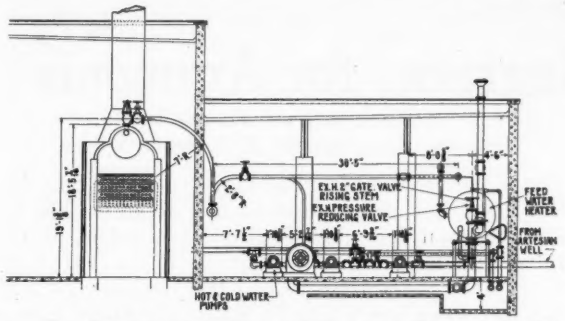


FIG. 5. SECTION SHOWING UNITS AND PIPING. TURBINE EXHAUST DIVIDES BEFORE REACHING FEED WATER HEATER

multi-port back pressure valve placed in the exhaust line, as shown at the right of Fig. 6. The exhaust line branches just ahead of this valve, one line feeding a 4500-hp. steel shell Hoppes feed-water heater, Fig. 6., the other line running underground to the canning factory, a total distance of a little over 500 ft. from the power plant.

There was also installed one 5-in. conduit carrying three 600,000 c. m. electric cables, one 4-in. cold water line, one 4-in. galvanized hot water line, one 4-in. high pressure steam line, one 8-in. low pressure steam main. The hot water and high and low pressure steam lines were insulated with 4-in. wood log, tin-lined covering furnished by the Michigan Stave Pipe Co. This covering was selected because of its high insulating qualities as well as because of the fact that the lines were run under the main line of a steam railway and the railway company objected to any other type of covering, their contention being that with any sort of vitrified duct, there was greater possibility of the duct cracking and permitting water to undermine the tracks. All high and low pressure steam lines and water lines, both in the power plant and in the factory, were covered with 85 per cent magnesia pipe covering.

Republic steam flow meters are used and are complete with indicating, recording and graphic devices; integrating watthour meters are installed on the electric services. Switchboard equipment consists of Westinghouse instruments, voltmeter, ammeter and indicating watthour meter, oil circuit breakers, etc.

At the power plant an artesian well was sunk to supply water for process work; this is a 10-in. well, 668 ft. deep, which has a capacity in excess of 500 gal. per min. and still shows a head of 2 lb. after pumping at this rate. Another well of the same size, but with a depth of 680 ft., was

FIG. 6. OPEN FEED WATER HEATER, WHICH ALSO FUNCTIONS AS A WATER SOFTENER, IS PLACED FOR CONVENIENT PIPING CONNECTIONS TO SERVICE PUMPS AND TURBINE EXHAUST

drilled at the north end of the factory to supply cold water for the canned goods as they come from the retort room. The pumping of this water heretofore had been an item of considerable expense, but the installation of this artesian well reduced this cost to a minimum as there is only the interest and depreciation on the well to meet, since the water flows from the well by gravity. It was found on test that this well would supply slightly over 400 gal. per min. without any pumping, which provides an abundance of water for cooling the product.

Three centrifugal pumps were installed, located as in Figs. 2, 4 and 5, one of 350-gal. per min. capacity for cold

FIG. 7. COOK ROOM IN FACTORY USES EXHAUST STEAM IN KETTLES, ELECTRICITY FOR LIGHTING AND HOISTS, AND COOLING WATER PUMPED FROM WELLS

water, one of 125-gal. capacity for either hot or cold water and one of 125-gal. capacity for hot water. These pumps are DeLaval centrifugals, single stage, designed to unload at 75 lb. and maintain a pressure of 60 lb. when operating at full capacity. They are driven by General Electric motors with hand starting compensators. The center pump can be used for either cold or hot water.

Feed-Water Heater Also Softens Water Without Use of Chemicals

Considerable study was given the subject of a water softener for this plant. An objection was raised to the zeolite and the lime and soda process softeners for this particular class of work, due to the likelihood of carrying over ingredients requiring additional sugar and salt in the brine solutions or other elements that had a tendency to darken the product. Upon investigation, the water was found to contain approximately 20 gr. of hardness, 14 of which were soluble and would be precipitated by application of heat. It was for this reason that the large open type feed-water heater was installed to use a considerable portion of the exhaust steam from the steam turbine. A practically soft water resulted, into which had been introduced no chemicals whatsoever, with the result that the canned product was absolutely free from any deleterious substances and the product was of a superior quality and texture.

Three Sprague electric hoists on a monorail serve to convey the baskets of canned products to and from the steam retorts. Two of these hoists are shown in operation in Fig. 7. A 75-hp. motor drives an exhaust blower which removes and stacks the corn husks, cobs, etc. Part of this equipment is seen at the left of Fig. 3.

Heater lines require an exceedingly close adjustment of temperatures. Each retort is individually operated by a Tagliabue control system, which maintains a predetermined temperature within the retort, which may be adjusted to any range for the various products. All of these retorts are now supplied with heat by means of exhaust steam from the steam turbine. With this combination it was found that the exhaust steam was superior to the live steam heretofore used.

One thing in particular was noticed this season: the entire operation required less supervision with remarkably fewer interruptions throughout the entire factory than there had been under the old system. It is planned, when the second boiler is in place, that a complete automatic control for the oil burners will be installed; the boiler efficiency, however, has run during the past season above 80 per cent.

Pressure-Total Heat Diagrams for Ammonia

Analysis of Ammonia Compressor Operation Made by Use of Ammonia Tables, Indicator Cards and Simple Data from Gages and Thermometers. By G. A. Robertson

STUDY OF THE pressure-total heat diagram of the refrigerating cycle, in conjunction with the pressure-volume diagram or indicator card, of ammonia compression, is not only interesting but instructive, clearly indicating heat and pressure relations at all points of the cycle.

It is not necessary to have an understanding of thermodynamics in order to work out the pressure-total heat diagram or to study the indicator card. A reasonable amount of common sense in the use of the ammonia tables and a little practice in obtaining areas of indicator card, is all that is necessary. It requires no more learning and energy to work out the pressure-total heat relations, having given the operating conditions. The data necessary are obtained by the use of thermometers and gages about the plant and the ammonia tables.*

The following operating conditions were taken at a plant where a vertical York machine was in operation on a test run:

Condenser pressure.....188 lb. ga. or 203 lb. absolute
Temperature of discharge gas taken at machine...
.....253 deg. F.
Suction pressure at the machine.....
.....19¼ lb. ga. or 34¼ lb. absolute
Temperature of suction gas at machine....13.5 deg. F.
Temperature of liquid at expansion valves, 76.61 deg. F.

Figure 1 is the pressure-total heat diagram for the foregoing operating conditions. Along the vertical line 1-2 are plotted absolute pressures and along the horizontal line 3-4 are plotted total heat values. The curve M N is the saturated liquid curve on the Mollier chart, that is the pressure-total heat curve of the liquid. If a number of absolute pressures are laid off on the line 1-2, and horizontal lines drawn through these points, or pressures, and if for each absolute pressure the heat of the liquid at a temperature due to that pressure, is found and laid off on line 3-4, and vertical lines drawn through these points until they intersect the horizontal lines, the intersecting points when joined together form the curve M-N.

Total Heat Found From Tables by Interpolation

Take as a starting point in the refrigerating cycle, the liquid just after it is condensed, that is the point A on the curve M N, which is at a pressure of 203 lb. absolute and at a temperature of 97.3 deg. F. and a total heat of 151.98 B.t.u. These values from circular 142, Bureau of Standards, page 25, are by interpolation as follows:

At 205 lb. pres...	97.91	deg. F....	152.7	B.t.u.
At 200 lb. pres...	96.34	deg. F....	150.9	B.t.u.
Per 5 lb. pres...	1.56	deg. F....	1.8	B.t.u.
Per 1 lb. pres...	0.312	deg. F....	0.36	B.t.u.
Per 3 lb. pres...	0.936	deg. F....	1.08	B.t.u.
At 200 lb. pres...	96.34	deg. F....	150.9	B.t.u.
At 203 lb. pres...	97.3	deg. F....	151.98	B.t.u.

The liquid, however, was precooled at a constant pressure from 97.3 deg. F. to 76.6 deg. F., having a total heat content of 128.1 B.t.u., circular 142, Table I, page 2, by interpolation as follows:

At 77	deg. F. tem.....	128.5	B.t.u.
At 76.0	deg. F. tem.....	127.4	B.t.u.
Per 1	deg. F. tem.....	1.1	B.t.u.
Per 0.6	deg. F. tem.....	0.66	B.t.u.
At 76.0	deg. F. tem.....	127.40	B.t.u.
At 76.6	deg. F. tem.....	128.1	B.t.u.

* Bureau of Standards Circular No. 142 contains complete tables of thermodynamic properties of ammonia and can be procured for 15 cents from the Superintendent of Public Documents, Washington, D. C. Additional copies of the Mollier Chart, as shown on page 49 of this circular, cost five cents each.

Therefore the next point found on the diagram is H. From point H the liquid passes through the expansion valve and the pressure drops from 203 lb. absolute to 34.25 lb. absolute. A vertical line through H intersects a horizontal line through 34.25 lb. at B, the next point on diagram. The total heat at B is the same as at H, that is 128.1 B.t.u.

During the evaporation of the liquid the pressure remains constant, and as the liquid evaporates it absorbs heat, hence the next line of the diagram is a horizontal line from B to the next point C. The point C represents the condition of the gas as to pressure and heat content just before it enters the compressor. From the data the pressure was 34.25 lb. absolute and the temperature 13.5 deg. F. The saturation temperature for 34.25 lb. absolute, is 5 deg. F. Therefore the gas going to the compressor was superheated 8.5 deg. and the total heat of the gas at 34.25 lb. absolute, and 13.5 deg. F., is 618.39 B.t.u.

Point C, is on the horizontal line through 34.25 lb. absolute and is 618.39 heat units from the vertical line through the zero point.

Compression Is Adiabatic With Constant Entropy

The gas passing through the compresser has its temperature and pressure raised. From the data the pressure was raised 203 lb. absolute and the temperature to 253 deg. F The compression is assumed to be adiabatic, constant entropy, energy expended during the compression stored in the gas, no heat added and no heat allowed to escape during compression. The total heat of the gas after compression was 736.1 heat units.

Since the gas, after leaving the compressor, is condensed at a constant pressure, the point D of the diagram will be on a horizontal line through 203 lb. absolute pressure, and at a distance of 736.1 heat units from the vertical line through zero point. Joining the points C, D and A completes the diagram, which represents the cycle the ammonia passes through in the refrigerating system, since from point D to A the gas is condensed and at A is a liquid.

Figure A H B C D represents the complete cycle of one pound of ammonia as it passes through the system, under the specified conditions as to pressure and temperature, given in the data taken at the plant. The total heat, specific volume and entropy values of the ammonia in the superheated state have, in the foregoing, been determined by the tables. This method gives one experience in becoming familiar with the ammonia tables; however, it is rather long and tedious and one is liable to make errors. It is more convenient, and the results are almost as accurate, to take these values, as well as those in the dry saturated state, from a Mollier chart. This chart is a graph of the ammonia tables, that is, the values of the several properties of a pound of ammonia are laid off, to scale, on the absolute pressure and total heat content lines, thus forming curves.

To determine the values at points A; H, B, C and D, from the chart, located 203 lb. pressure on the vertical line at the right hand side of the chart, follow horizontal line from this point until it intersects the saturated liquid curve, giving the point A. The total heat value at this point is read from the top horizontal line of the chart. Continue the 203 lb. horizontal line until it intersects the 253 deg. curve, giving point D. Total heat value at this point is read from the top horizontal line. The 203 lb. line also intersects the entropy line at D, thus giving the value of the entropy of the vapor at 203 lb. and 253 deg. Since the compression is at constant entropy, follow the entropy line until it intersects horizontal line through 34.25 lb. absolute pressure, giving point C; total heat at this point is read on the bottom horizontal line of the chart by following horizontally through 34.25 lb. pressure until it intersects the vertical line through 128.1 heat units, laid off on the bottom horizontal line. This point of the intersection is point B of the diagram, a vertical line through B intersects the horizontal line through 203 lb. at H, and horizontal line through H intersects the saturation liquid curve at A, which completes the diagram.

Superheat Must Be Accounted for

Since the temperature of the gas at the machine indicates superheat, the total heat at C was found. Had there been no superheat in the gas the total heat would

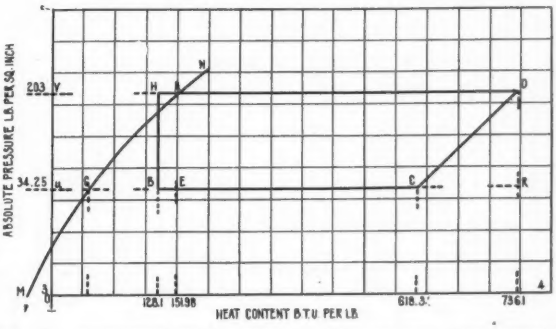


FIG. 1. PRESSURE-TOTAL HEAT DIAGRAM FOR CONDITIONS FOUND ON TEST

then be found by the heat of the liquid at absolute suction pressure, plus the quality of the gas, times the latent heat of the gas at suction pressure. The quality X is found by the entropy equation $s + X\frac{L}{T} = S$, in which s equals the entropy of the liquid at suction pressure, $\frac{L}{T}$ equals entropy of evaporation at suction pressure, X equals the per cent of gas in mixture of gas and its liquid and S equals the entropy of compression, the same at C as at D.

In Fig. 1, the line GB equals UB minus UG equals the heat of the liquid at 76.6 deg. minus the heat of the liquid at 34.25 lb. pressure or 5 deg. F. saturation temperature. The line GB represents the heat units removed from the liquid in reducing its temperature from 76.6 to 5 deg. This cooling is done at a loss of available heat in the pound of ammonia as it passes through the cycle.

Since GB equals UB minus UG or 128.1 minus 48.3 equals 79.8 heat units or B.t.u.

Line BE or HA represents the saving of heat available by precooling the liquid from 97.3 to 76.6 deg.

BE equals UE minus UB or 151.98 minus 128.1 equals 23.88 B.t.u.

Line BC represents the remaining available heat, or the refrigerating effect of one pound of ammonia as it passes through the cycle. BC equals UC minus UB or 618.39 minus 128.1 equals 490.29 B.t.u.

Line CR represents 117.71 B.t.u., the heat added to the gas in the form of work or energy, when compressed. This 117.71 B.t.u. per pound is the sum of the work

required to raise the pressure and temperature of the gas and to discharge it from the compressor.

Line AD represents 584.1 heat units removed from the gas in the condenser.

Heat units removed in condensing the gas and precooling the liquid is UR minus UB equals 608 heat units. A study of the diagram AHBCD, gives one a fairly clear conception of the pressure heat relations of the ammonia as it passes through the cycle.

Indicator Card Represents Work Done on Gas

In Fig. 2, FGHI represents the theoretical indicator card of the compression of one pound of ammonia gas, at the pressures and temperatures of the refrigerating cycle in the foregoing paragraphs. It would be somewhat difficult actually to draw the card to scale, on account of plotting the curve of compression HG; however, the figure can be used to show the distribution of the work at desired points in the stroke. FGHI represents the work or heat

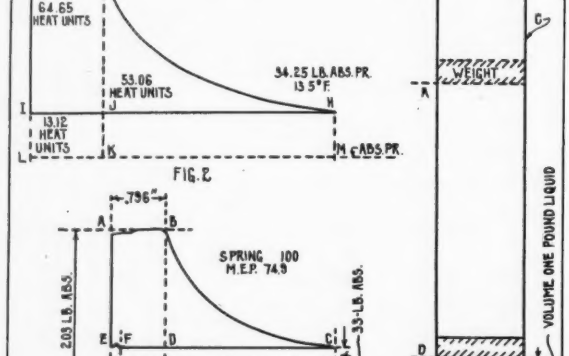


FIG. 2. THEORETICAL INDICATOR CARD FOR ONE POUND OF AMMONIA GAS UNDER CONDITIONS GIVEN

FIG. 3. GRAPHICAL REPRESENTATION OF EXTERNAL WORK DONE ON AMMONIA GAS IN CYLINDER

FIG. 4. ACTUAL INDICATOR CARD TAKEN FROM COMPRESSOR UNDER TEST

of compression, which is 117.7 B.t.u. Part of this heat is expended in raising the pressure and temperature of the gas and the remainder in discharging it into the condenser.

Figure FGHML, above the zero absolute pressure line, represents the total work done on the gas confined between the piston and cylinder head of the compressor. The gas when entering the compressor performed work on the piston as represented by IHML on the card. In the figure FGHML the total heat or work of raising the pressure and temperature is represented by KGHM and the total heat or work of discharging the gas into the condenser is represented by FGKL. This latter heat or work is equivalent to the external heat of the gas as it enters the condensers. Consider that in the cylinder C, Fig. 3, there is a pound of liquid ammonia at a temperature of 97.3 deg. F., and on this liquid there is a weight of 203 lb. per sq. in. absolute pressure. If heat is added to the liquid until it is evaporated the weight would be moved upward from point D to point A, the weight moving through a distance representing work and such work when expressed in heat units, is external heat of the gas. If the gas is cooled until it is liquefied the weight drops to its original position and in so doing does work, which is equivalent to the external work of the gas. The compressor piston, in discharging the ammonia gas into the condenser to be liquefied, performs work equivalent to the external heat of the gas. In Fig. 3 the distance AD represents the change or increase in volume, and is equal to the specific volume less the volume of the liquid, likewise the volume per pound of the gas, at point G on the card, Fig. 2, is the change in volume, or the specific volume less the volume of one pound of liquid in the condenser. The specific volume of the gas at G is 2.097 cu. ft. The specific volume of the liquid in the condenser, or at 203 lb. absolute pressure and 97.3 deg. F., is 0.02736 cu. ft., by interpolation the change in volume is 2.097 minus 0.02736 or 2.07 cu. ft. The external heat of the gas is the change in volume times the pressure in pounds per square foot, divided by 778 (foot pounds per B.t.u.). The external heat of the gas at point G on the card is

$$\frac{2.07 \times 203 \times 144}{778} = 77.77 \text{ B.t.u.}$$

On the card shown by Fig. 2, FGKL represents 77.77 B.t.u., and IJKL represents 13.12 B.t.u., that is the volume in the latter figure is the same, but the pressure less, as follows:

$$\frac{2.07 \times 34.25 \times 144}{778} = 13.12 \text{ B.t.u.}$$

Finding Work Done by Compressor

Work done by the compressor in discharging the gas into the condenser is represented on the card by FGJI or 64.65 B.t.u.

Total work done by the compressor on the gas, as it passes through the compressor, is 117.71 B.t.u.

Heat of compression expended in raising the pressure and temperature of the gas is represented by GHJ, being equal to 53.06 heat units.

Figure 4 is a copy of indicator card taken from the single acting compressor in the plant where the operating data used in the foregoing paragraphs was taken.

Scaling the card the discharge pressure is found to be 203 lb, abs., and the suction pressure at C is 33 lb. abs. The total area of the card is 2.5 sq. in., the area of ABDE is 1.31 sq. in., and the area of BCD is 1.19 sq. in.

The length of the card is 3.336 in. The spring used is 100 lb. to the inch and the mean effective pressure is

$$\frac{2.5}{3.336} \times 100 = 74.9 \text{ lb.}$$

Diameter of the compressor is 15 in., the area 176.71 sq. in., the length of stroke 22 in. or 1.83 1/3 ft., and the revolutions per minute 56.

Energy or heat expended by the compressor on the gas per minute, that is the horsepower expressed in heat units, is $\frac{176.71 \times 74.9 \times 1.8333 \times 56}{778} = 1746.6$ B.t.u. per min. The heat of compression, per pound of ammonia, as shown by the indicator card, Fig. 4, is as follows: The external heat of a pound of gas as it enters the condenser at 203 lb. abs., and at 253 deg. F., is equal to 77.77 B.t.u., and the change in volume is 2.07 cu. ft.

The heat expended, represented by EDGH, is equal to $\frac{2.07 \times 33 \times 144}{778}$ or 11.36 B.t.u. The heat expended by the compressor in discharging one pound of the gas, represented by ABDE equals ABGH minus EDGH or 66.41 B.t.u.

Heat expended by the compressor in raising the pressure and temperature of the gas is 90.8 per cent of the heat of discharging the gas, therefore the heat represented by BCD is 66.41 × .908 or 60.3 B.t.u. Therefore the heat of compression per pound of ammonia gas is equal to 66.41 + 60.3 or 126.71 B.t.u. The total heat, or work, expended by the compressor per minute on the several pounds of gas that passed through the compressor per minute is 1746.6 B.t.u. The heat required to compress one pound of gas is 126.71 B.t.u. Therefore the pounds of gas that passed through the compressor per minute is 13.78.

Accounting for Clearance

Foregoing equations relating to the indicator card, Fig. 4, do not take into consideration the clearance or re-expansion of the gas left in the cylinder at the end of the stroke.

Scaling the card, the suction valve opens at F, or 1/10 in. from E, the end of the stroke.

One-tenth in. divided by 3.336 in. = .03 or 3 per cent of the stroke. Therefore 97 per cent of the compressor was filled with gas from the suction pipe for each revolution. 13.78 × .97 equals 13.37, the actual pounds of ammonia through compressor per minute.

The line BC in Fig. 1 represents the refrigerating effect of a pound of ammonia. The heat unit value or the refrigerating effect is 490.29 B.t.u. Therefore the total refrigerating effect per minute equals 13.37 × 490.29 or 6555.97 B.t.u.

A ton of refrigeration per 24 hr. is at the rate of 200 B.t.u. per minute or 200 × 1440 = 288,000 B.t.u.

The refrigerating effect in tons of refrigeration will then be 6555.97 divided by 200 equals 32.7798 T. of refrigeration, and for the two compressors, 32.7798 × 2 = 65.56 T., which is the refrigerating capacity of the compressor as shown by the indicator card, when the compressor was operated under the conditions as given in the foregoing. The data used in the foregoing were taken from the report of the test of a 15 by 22-in. single-acting York machine at the plant of the Eastman Kodak Company, Rochester, N. Y., March 10, 1908.

During this test the refrigerating load on the machine was determined by the weight of brine, and the temperature reduction of brine through a brine cooler. The brine tonnage was 63.91 T. of refrigeration per 24 hr. There was a refrigeration loss in the suction pipe between the brine cooler and the compressor, of about 0.5 of a T. of refrigeration per 24 hr., making a total recorded tonnage on the compressor of 64.41. Then $\frac{65.51 - 64.41}{64.41} = 1.6$ per cent, which shows the indicated compressor capacity to be within 1.6 per cent of the measured capacity.

The indicated horsepower from the ammonia card (Plan) $\frac{74.9 \times 1.8333 \times 176.71 \times 56}{33{,}000} = 40.57$ hp.

(33,000)

and for the two compressors, 40.57 × 2 or 81.14 hp.

The indicated compressor horsepower per ton of indicated refrigerating capacity equals 81.14 divided by 65.51 or 1.13 hp.

Heats units required to compress one pound of ammonia has been shown to be 117.71. The pounds of ammonia through one compressor per minute was 13.37 lb. and through the two compressor cylinders it was 26.74 lb. per min.

The theoretical horsepower is then

$$\frac{26.74 \times 117.71 \times 778}{33{,}000} = 74.17.$$

Theoretical horsepower per ton of indicated refrigerating capacity equals 74.17 divided by 65.51 or 1.13 hp. The indicated horsepower of the steam engine driving the compressor was given in the report of the test as 89.48 hp., therefore the indicated engine horsepower per ton indicated refrigerating capacity equals 89.48 divided by 65.56 or 1.36 hp. The calculated capacity of the compressor, without clearance, leakage, or loss due to hot cylinder walls is obtained as follows:

Area of compressor in cubic feet equals 1.227. Cubic feet per min. equals 1.227 × 1.8333 × 56 × 2 or 252 cu. ft. displacement per min. Weight per cubic foot of suction gas at 34¼ lb. abs. and 13.5 deg. F. is 0.1199 lb. per cu. ft. The calculated tons of refrigeration per 24 hr.

$$\text{equals } \frac{252 \times .1199 \times 490.29}{2000} = 74.06 \text{ T.}$$

This foregoing discussion appears rather long and tedious; however, with practice in using the ammonia tables and drawing total heat diagrams on the Mollier chart, the work can be done in a comparatively short time. The calculation of the indicated refrigerating compressor capacity can be shortened by the use of compressor constants.

Wood Waste Successfully Burned

WOOD WASTE from its body building plant is to be used as fuel by Willys-Overland, Inc., of Toledo, in conjunction with coal, in the boiler room which will supply power to its large new drop forging plant. The coal will be burned on six Taylor underfeed stokers of the modern long type under the like number of 640-hp. boilers. Chutes and a conveyor system will introduce the wood above the stoker fuel bed, as is now being done at the plant of the Fisher Body Corp., Detroit, where similar stokers are used. The Fisher Body Corp. plant is now 2 yr. old and its experience has shown that this method of burning wood waste is entirely practicable. At the Fisher Body plant there are four boilers of 750 hp. each.

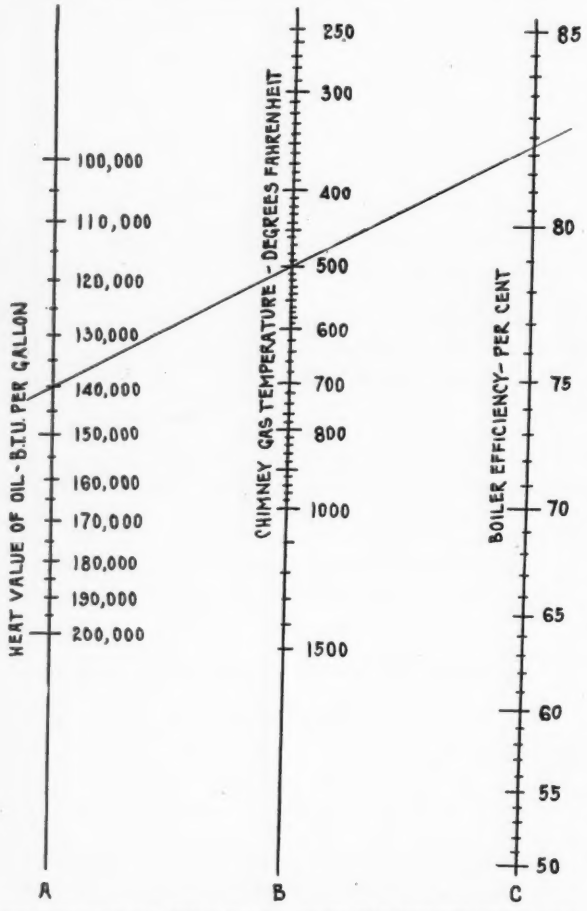
It is planned to operate the Willys-Overland boilers at an average rating of over 200 per cent but when necessary, they can be forced to nearly 300 per cent to take care of peak loads. Stokers of the type used have a flat efficiency curve, even at ratings as high as 400 per cent and respond quickly to sudden demands for steam, which makes them especially adapted to plants of this kind, where the load is likely to change rapidly without warning. Experience has shown that the introduction of wood above the fuel bed makes but little difference in the performance of the stokers.

Efficiency of Oil-Fired Boilers

By W. F. Schaphorst

THIS HANDY little chart will quickly give the approximate efficiency of any boiler that is oil-fired, knowing the heat value of the oil and the temperature of the chimney gases.

Simply run a straight line through the heat value of the oil in B.t.u. per gallon in column A, and through the chimney gas temperature in degrees F., column B, and the intersection of the straight line in column C gives the approximate boiler efficiency in per cent.



RELATION OF OIL HEAT VALUE, FLUE GAS TEMPERATURE AND BOILER EFFICIENCY

For example, the solid line running across this chart shows that if the heat value of oil is 140,000 B.t.u. per gal. and if the chimney gas temperature is 500 deg. F., the boiler efficiency should be about 82.2 per cent.

This chart is based upon the following simple rule which was developed by the writer. It is not claimed to be "absolutely accurate" but for general use it will be found to give surprisingly close results. The rule is:

"Multiply the chimney gas temperature in degrees F. by 5000 and divide by the heat value of oil in B.t.u. per gal. Subtract the result from 100. The remainder is the approximate boiler efficiency in per cent." Thus applying this rule to the above example where the temperature is 500 deg. F. and the heat value of the oil 140,000 B.t.u. per gal., we get $500 \times 5000 = 2{,}500{,}000$. Dividing by 140,000 we get 17.8. Subtracting from 100, the result is 82.2 per cent as shown by the chart.

It is obvious that if combustion is complete and if we have a low chimney gas temperature, the boiler efficiency is bound to be high because the heat certainly has been absorbed by the boiler. The heat must go somewhere and the higher the chimney gas temperature the lower the boiler efficiency, as indicated by this chart.

Careful study of the chart shows how important it is to maintain a low chimney gas temperature and avoid high temperatures. It also shows that oils of high value are likely to give higher boiler efficiencies than are oils of low heat value, the chimney gas temperature being the same in all cases.

A number of years ago the writer developed a chart of this type based on coal as the fuel and found that it gave exceedingly good results and for that reason he is now presenting this chart for the benefit of those who are burning oil under their boilers.

Industrial Simplification Progresses

REPORT of estimated savings of $293,600,000 annually by nine groups of industries, which have adopted simplified practice standards in their products, has increased the interest in the war on waste which is being waged in co-operation with the Simplified Practice Division of the Department of Commerce. More than 40 conferences were held in the second quarter of 1925, the most important projects having to do with American lumber standards and with the sash, door and millwork industry.

As an instance of what can be done, reduction from 6280 to 4700 varieties and sizes of paper bags is estimated to save $600,000 a year. Cuts of 84 and 83 per cent in variety of dining car and hospital chinaware, elimination of 342 out of 480 sizes and shapes of paint brushes and cut of 62 per cent in rubber sizes for elastic webbing are examples of what is being done.

Initial steps are now being taken for conferences on dozens of other products, some of those which specially interest power plant men, being bank checks, glass sidewalk and skylights, power boilers and accessories, shovels, carbon brushes, brass valves and fittings, rods and stuffing boxes, heating and piping supplies. A number of subjects have been brought to the attention of the American Engineering Standards Committee, the Society of Automotive Engineers and the Rubber Association of America for investigation and recommendation.

L. W. Wallace of the American Engineering Council, Gen. H. C. Smithers of the Bureau of the Budget and B. H. Ackles of the National Supply and Machinery Distributors Assn., have been added to the advisory commission of the division to give more complete representation of factors interested in waste elimination.

AMPLE AND ADEQUATE settling storage capacity should be provided in connection with turbine circulating oil systems, so that the oil will have a chance to settle out the water and other impurities gathered up in its circulation through the system and so it will have time to radiate its heat content. It is advisable to install cooling coils in running water tanks through which the oil may pass and be cooled.

Novel Design of Metallic Packing Stands Test of Time

ABOUT 10 YR. ago I had so much trouble with the packing on the piston rods of my engines and pumps that I finally worked out a design of metallic packing which has given excellent service ever since installing and has received no attention all these years.

In Fig. 1 is shown the packing assembly and details of construction. Six segments, cast from high melting point babbit, are required. They may be made to fit a rod of any diameter. These segments interlock in such a way that no steam can blow through and are held together by coil springs made of No. 20 steel spring wire.

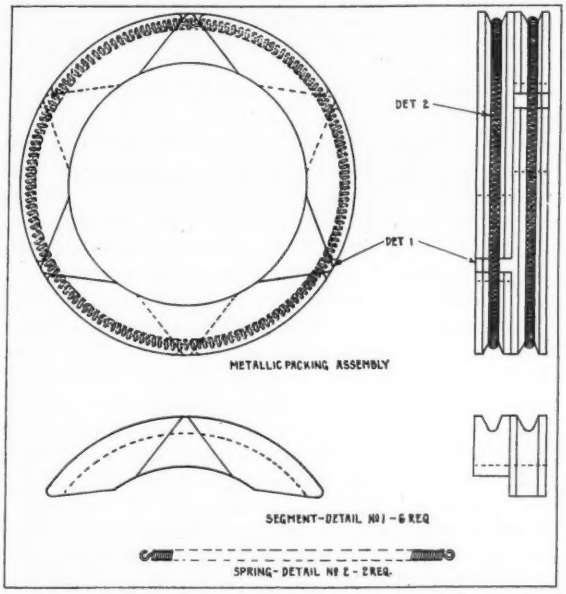


FIG. 1. ASSEMBLY OF SEGMENTS OF METALLIC PACKING CAST FROM BABBIT, INTERLOCK AND ARE HELD TOGETHER BY COIL SPRINGS

The ends of each of these coil springs are hooked together and dropped into the two annular grooves found in the periphery of the packing assembly as shown in detail No. 2 of Fig. 1.

This metallic packing assembly firmly grips the rod and when put in place, no steam can escape. The assembly shown in Fig. 1 is now in use on a 3¼-in. diameter rod of a Corliss engine. In addition to use on all the main piston rods of direct-acting pumps, I have found it gives excellent service on all valve rods.

This packing is installed as shown in Fig. 2. After all old packing has been removed, an asbestos gasket which loosely fits the rod is slipped over the end of the rod and pushed to the back of the stuffing-box. A special cast-iron sleeve is then slipped over the rod and pushed against the asbestos gasket. This sleeve fits the rod loosely enough not to touch it. Next, the metallic packing is assembled on the rod and pushed into the cup-shaped, annular space

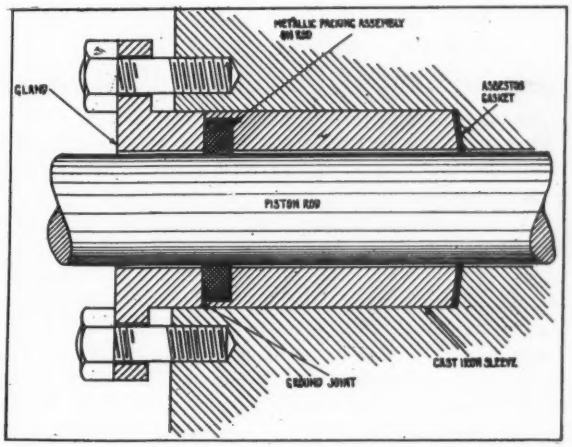


FIG. 2. ANNULAR RECESS IN CAST-IRON SLEEVE PREVENTS PRESSURE OF GLAND AGAINST PACKING

between the rod and sides of the cast-iron sleeve, found in the outer end of the sleeve. The outer end of the sleeve is smoothly ground, as is the inner surface of the packing gland. This gland is then drawn tightly against the sleeve.

The cup shaped space in the sleeve is deep enough that there is a clearance of 0.001 in. on either side of the packing ring and the diameter of the cup is such that when the packing ring is pushed into it there is a clearance of about 1/32 in. between the rim of the packing ring and the sides of the cup. These clearances allow the packing to expand in all directions.

During 10 yr. of service with the original metallic packing, there has been no appreciable wear on the rods and they have become highly polished. Positive assurance against steam leakage is given by the manner in which the segments interlock.

Chicago, Ill. FRANK HERLE.

Following the Golden Rule in Business

SOMETIMES a little favor or a helping suggestion pays good dividends, although, for some reason, it seems that certain concerns do not include service to the public in their policy.

Not long ago, when visiting the office of one of the largest electrical corporations, I saw posted on the wall a copy of their president's first letter to his employes. It was to the effect that the success of any business not only

depends on courtesy to prospective customers but good will and service to everybody, since any company depends on the public for its very existence.

But often there are others not so considerate. Three years ago the writer took charge of a plant and, not being familiar with one of the engines, wrote to the manufacturer for information. A stamped and self-addressed envelope was enclosed but, for some reason, the request was entirely ignored.

Some time later, when we were planning on enlarging our plant, the manager was in favor of the purchase of another engine of this make, but on learning of the manufacturer's discourtesy and indifference, decided to try another type, not because it was any better but for the sake of the principle involved.

Any company which forgets all about old customers after the bill has been paid is not worthy of attention.

Boston, Mass. CHAS. MAGNUS.

New Method of Pulverized Coal Firing

IN REFERENCE to the editorial in the issue of July 1, "What is a B.t.u.?" I would like to call attention to what I consider phenomenal results in burning pulverized coal while making tests with a new pulverized coal system on a forging furnace, formerly using crude oil as fuel. I was advised that this furnace required an average of 174 lb. oil per hour and had used oil burners of apparently average efficiency. With the new pulverizer I obtained the same results with 140 lb. pulverized bituminous coal per hour and yet on the basis of an equal number of heat units it should have required 254 lb. coal per hour. There could be no more convincing argument in favor of pulverized coal than the saving of 114 lb., or 1,482,000 B.t.u. per hr.

In comparative tests of time necessary to heat the same weight of steel, it required 20 min. with oil and 12 min. with pulverized coal. This meant a saving of 8 min. for each charge of metal in the furnace.

With a mixture of about 40 per cent bituminous and 60 per cent anthracite, I have produced flame temperatures far above those ordinarily obtained with bituminous coal alone, the appearance of the flame indicating a temperature almost as high as that produced by an electric arc. With this mixture of bituminous and anthracite coal, almost instantly after leaving the burner, the burning gases change into a colorless flame, which indicates a higher initial temperature.

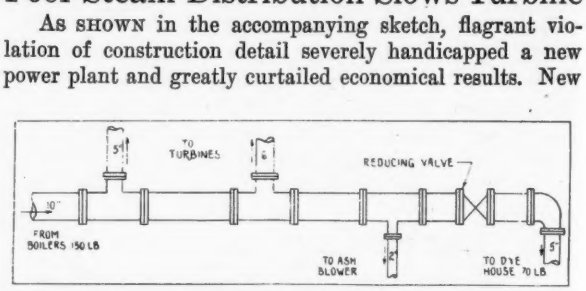
Only by a strictly uniform feed of fuel intimately mixed with the proper amount of air, can the above conditions be produced. In experimenting with this system, I have always obtained results far above my expectations and I am also inclined to think that our accepted value of a B.t.u. may be wrong. I also believe that the large combustion space now used under super-power boilers fired with pulverized coal may be reduced 50 per cent and still produce as high or higher efficiencies than at present.

At the present time I am making tests with this system on a small residential furnace of the hot air type for a six-room house. In this furnace I have constructed a combustion dome which prevents the extreme heat of combustion from coming into direct contact with the cast metal and serves as an economizer. The heat storage space in the dome is 1½ cu. ft. Upon initial firing it requires only about 7 lb. of coal to raise the room temperatures to normal, while heating 300 lb. of refractories contained in the combustion dome to 2000 deg. F. Then the fuel supply may be shut off, damper practically closed and the heat stored in the combustion dome gradually released to the heating surface of the furnace for several hours. After that it requires only about 4 lb. of coal to bring the temperature of the combustion dome or heat storage space up to the above temperature. By this method of conserving heat, it requires only about 11 lb. of coal to produce the same results as burning 50 lb. of coal when hand firing and at the same time entirely eliminating smoke. Readers may not be interested in residential heating, but I believe this will give some indication of the possibilities of pulverized coal firing and the high efficiency that may be obtained.

Cleveland, Ohio. CHAS. I. FILSON.

Poor Steam Distribution Slows Turbine

AS SHOWN in the accompanying sketch, flagrant violation of construction detail severely handicapped a new power plant and greatly curtailed economical results. New



AUXILIARY LINES ROB TURBINES OF STEAM

construction poorly designed is expensive and the changes necessary to rectify this trouble cost as much as the original installation. The fault was apparent and should have been evident to the designer; however, the operating crew were on the alert and quickly discovered the difficulty. The line drawing represents a layout of a main steam header feeding two noncondensing steam turbines which in turn drive a.c. generators. Off one end of the turbine line was a steam jet ash blower connection. This blower worked exceedingly well; however, it was a bit expensive to operate working on superheated steam.

Next to this was a reducing valve feeding a 5-in. line to a dye house. When steam was drawn through this line it was almost the same as blowing into the open air. The throttle pressure of the turbine dropped and the speed of the turbine was reduced. When the frequency fell off all the plant motors began to slow down, which lowered production rates.

To remedy the trouble the dye house and ash blower line were cut off the header and taken from the farthest point in the boiler room away from the turbines. This served to rectify the trouble.

Practically the same amount of steam was used but the distribution into the proper channels eliminated the trouble, provided for constant speed for the turbine, furnished the dye house with sufficient steam for steady operation and eliminated the necessity for shutting off at intervals to allow the pressure to build up at the turbine throttle.

Chicago, Ill. H. M. TOOMBS.

BEFORE BLOWING sediment from a boiler, firing should cease for a few minutes if possible, in order that circulation may cease and allow floating scale or other foreign matter to settle to the mud drum.

Old Belt Makes Good Packing

ONE OF OUR triplex pumps ordinarily had been packed with braided flax packing but the last time it needed repacking we ran short of the kind used. To meet the emergency, we took out the best pieces, turned them over and hammered them into shape as well as possible. To replace the badly worn or broken pieces, we cut strips of used rubber belting, 5/8 in. square and long enough to encircle the piston rod.

A handy means of cutting the strips was found by laying the old belt flat on a board and then, by means of C-clamps, holding a piece of 5/8-in. bar iron firmly to the belt. With a sharp knife the belt was then cut along both sides of the bar. This provided a strip with sides exactly parallel and 5/8 in. square at all points.

Since the piston rod was 7 in. in diameter, strips were cut 23 in. long and the ends beveled with the layers of canvas of the belt in a plane perpendicular to the rod.

In filling the gland, the method of packing was to alternate each of the new strips with a piece of the old flax packing, oiled and graphited. This is illustrated in Fig. 1.

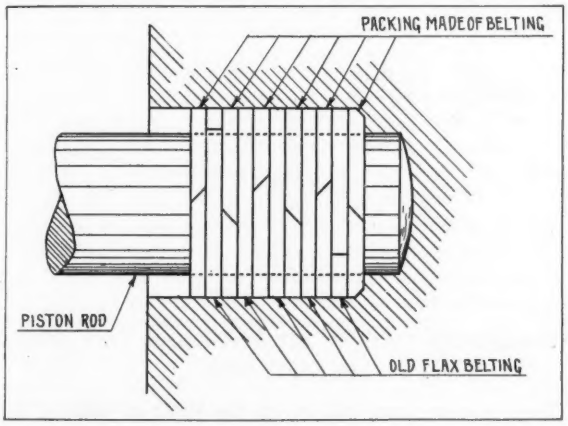


FIG. 1. ALTERNATE STRIPS OF RUBBER BELT AND REGULAR FLAX PACKING PLACED IN PUMP GLAND

In the packing of any gland, the smoothness of the rod should be of prime consideration as no sort of packing will endure a scored rod. The excellent service obtained with our emergency packing has been due, no doubt, to the care we took to provide a smooth rod.

Another "kink" which may be of interest is shown in Fig. 2. A globe valve which had to turn easily for quick closing was placed in a line which had enough vibration to close or open the valve slowly. To prevent this, one end of a screen door spring was wired to the pipe and the other end made into a book which held the hand wheel at any desired position.

Death Valley, Cal. CHAS. LABBE.

Engineering Opportunities

YOUR ISSUE of August 1 contains an interesting article by Louis R. Lee, on Engineering Opportunities, in which he expresses views of much value. There is, however, one statement with which I am inclined to disagree, to the effect that "In most cases opportunities for advancement are equal."

My observation is, that although this may represent an ideal condition for which one might piously hope, it does not accord with the observable facts and perhaps after all it may be as well that this is so, for is not character developed by facing the facts of life as they really are and using our utmost intelligence and effort to overcome them?

From my experience in interviewing a large number of young men applying for membership in one of our engineering societies, I am convinced that one of the greatest difficulties confronting the technical graduate, is to obtain accurate and unbiased data relating to opportunities in the engineering field. He can get an unlimited quantity of advice of the "Be good and you will be happy" order, but, when it comes to a clear and unbiased statement of the conditions actually existing in business life, the available supply appears to be woefully inadequate.

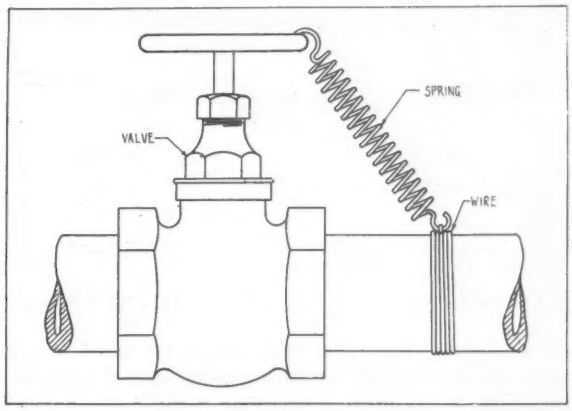


FIG. 2. SCREEN DOOR SPRING HOLDS VALVE IN ANY POSITION

I am convinced that this state of affairs is causing great economic loss, as I have met comparatively few young men who are in a line in which they are willing to stay permanently.

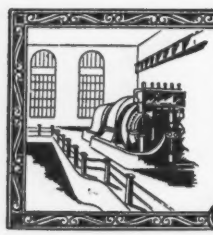
In most cases, they have drifted into their work because it represented one of the first and immediately the most remunerative opportunities which offered after their graduation. They know little about the real opportunities and requirements in their own line and spend much of their time dreaming about the supposedly better opportunities in other lines, about which they know even less.

It is, I think, a blot on our educational conditions, that hundreds of young men are being turned out by our colleges every year without reliable information upon which to base a decision as to their life's work. They are simply left to find their places by the unscientific cut and try method, now discredited as being too inefficient to be applicable to modern industrial conditions.

Although I have come to these conclusions independently from my own experience, I cannot claim originality, as the late Prof. Hugo Muensterberg of Harvard was evidently keenly alive to the conditions and discusses them in his works; but, although I believe the problem received some consideration in his time, I have yet to meet a technical graduate who has found the necessary information available to him at present and I have met few who have not felt the need of it at some time.

This is, I think, a matter which should receive the consideration of our colleges, engineering societies and all those who are interested in the welfare of the engineering profession.

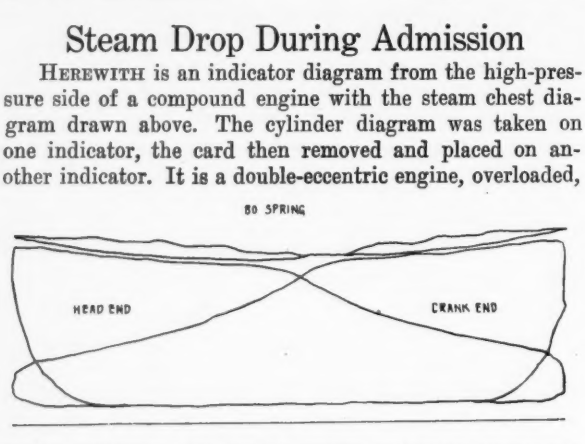
New York. J. O. G. GIBBONS.



QUESTIONS AND ANSWERS

Steam Drop During Admission

HEREWITH is an indicator diagram from the high-pressure side of a compound engine with the steam chest diagram drawn above. The cylinder diagram was taken on one indicator, the card then removed and placed on another indicator. It is a double-eccentric engine, overloaded,



STEAM CYLINDER AND STEAM CHEST DIAGRAMS COMPARED

and it seems to the writer that there is too much drop in pressure from the time steam valves are opened until they are closed. What do other engineers think?

TOM JONES.

What Causes Corrosion in a Hot Water Heater?

PLEASE ADVISE what will prevent corrosion and pitting in a hot water heater. A few months ago we took the tubes out of an old boiler, welded plates over the header openings and put in brass tubes for steam coils. We have been heating the water to about 150 deg. F. and we find that rapid corrosion is taking place. We use untreated water from the city mains. J. F. S.

A. Corrosion such as you state you are experiencing in your water heater may be due to various causes and we would suggest that you immediately submit a sample of the water to some reliable concern specializing in the treatment of boiler feed water.

The corrosion may be due to magnesium chloride or sulphate that would require treatment with an addition of sodium carbonate. Free acid would require a neutralizing alkali. Dissolved carbonic acid and oxygen would require heating the water, keeping it free from air and perhaps the addition of a small amount of slag, lime or caustic soda. Grease or oil would require filtering, the use of iron alum as a coagulant, or neutralization by sodium carbonate. Organic matter would require filtering and the use of a coagulant.

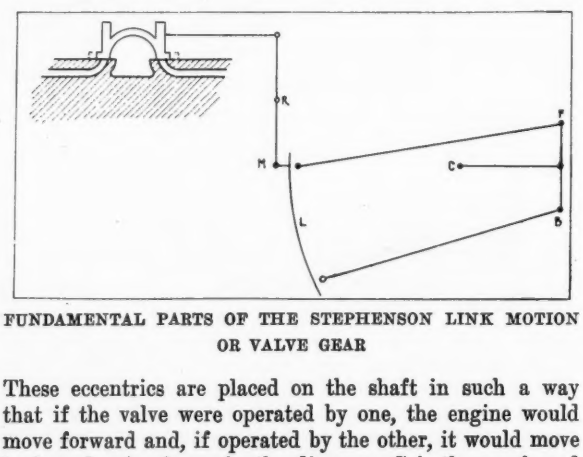
Sometimes where an iron condenser or a heater is provided with brass or copper coils galvanic action is set up, and this may be overcome by fastening zinc plates to the tubes. In this way chemical action would be between the zinc and copper, instead of between iron and copper.

An old remedy still in use is that of applying a thick coat of red lead mixed with boiled linseed oil. Clean the corroded surface and allow to dry before painting. There are companies which furnish internal boiler paints composed mostly of graphite, and which in many cases have given excellent results.

Purpose of Stephenson Link Motion

WHAT IS the purpose of the Stephenson link motion? J. H. C.

A. In the Stephenson link motion, as shown in the accompanying figure, a forward eccentric, F, and backing eccentric, B, are connected by rods to the opposite ends of a slotted link, L. This type of valve gear is used for reversing an engine and for varying its points of cutoff.



FUNDAMENTAL PARTS OF THE STEPHENSON LINK MOTION OR VALVE GEAR

These eccentrics are placed on the shaft in such a way that if the valve were operated by one, the engine would move forward and, if operated by the other, it would move backward. As shown in the diagram, C is the crank and R the rocker arm.

The link being attached to the ends of the two eccentric rods, receives a rocking motion. A movable block, M, to which the valve rod is attached, is carried in the slot of the link. When the block is at the end of the link next to the forward eccentric, the engine will move forward. When the block is at the other end, the engine will be reversed. As the block is moved nearer the intermediate position, travel of the valve becomes less, consequently the cutoff becomes earlier. When the block is in the central position the travel of the valve is not enough to uncover the ports, consequently the engine remains at rest.

Does the Chimney Have Proper Dimensions?

WE HAVE eight 300-hp. water-tube boilers which are to be operated at 300 per cent of rating. Each furnace has 50 sq. ft. of grate area. The chimney is 175 ft. high and 9 ft. inside diameter, while the main smoke flue is 4 ft. 9 in. by 7 ft. 6 in. cross-sectional area. Are the chimney and smoke flue the right size? R. G. M.

A. You have not stated whether the draft is natural or forced, the amount of coal to be burned per boiler

horsepower, or if stated another way, the efficiency and the heat value of the coal. Also, we doubt if it would be possible to obtain 300 per cent of rating with 300 hp. boilers with only 50 sq. ft. of grate surface. This gives a ratio of heating surface to grate surface of 60 to 1, which is entirely too much for such a high rating. Without going any farther than comparing the area of a cross section of the chimney with the area of a cross section of the main flue, we find that the chimney has an area of 64 sq. ft. and the flue area is 36 sq. ft. The flue should be as large as the area of the stack, but even if we were to assume that it is as large, we find that the area of the stack is not large enough to handle the amount of gases produced at maximum rating. We will assume 4 lb. of coal burned per boiler horsepower. The total output in boiler horsepower, as given, is 7200. $7200 \times 4 = 28{,}800$ lb. coal. We will also assume 20 lb. of gas produced per pound of coal. We shall then have 576,000 lb. of flue gas to be handled by the stack per hour. We will also assume the temperature of the gas entering the stack to be 600 deg. At this temperature the weight of 1 cu. ft. of gas = 0.0374 lb. If we have 576,000 lb. of gas per hr., this will be 160 lb. per sec. Then, $160 \div 0.0374 = 4280$ cu. ft. per sec.

We will now assume a velocity of 25 ft. per sec., that is, also assuming that there is no undue restriction between the boilers and the stack and that the cross sectional area of the main flue is the same as the stack area. Dividing 4280 by 25, we get 171 sq. ft. as the needed area of the stack. This gives a diameter of 14 ft. 9 in.

We must next determine the needed height of stack. To do this, we must know the amount of available draft. You have not stated the various draft losses through the fuel bed, through the boiler and damper and also the drop caused by different turns in the breeching. We will, therefore, assume that the total draft required is 1.25 in. of water. The formula for determining the height of a chimney is as follows:

$$H = \frac{d}{K - \frac{F W^2 C}{A^3}}$$

where,

d = the available draft or the total draft required.
K = a constant.
F = a factor for frictional loss.
W = pounds of gas per second.
C = the perimeter of the stack in feet.
A = the area in square feet.

In this case K for 600 deg. temperature = 0.0075 and F = 0.0015. Then

$$H = \frac{1.25}{0.0075 - \frac{0.0015 \times 160^2 \times 46.45}{171^3}}$$

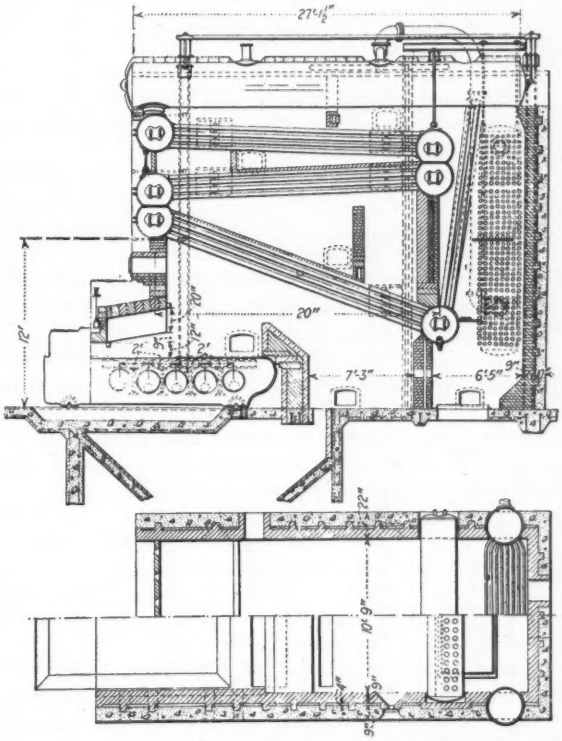
This gives approximately 175 ft. as the height needed for the stack.

These results show that your stack is of the correct height but not large enough in diameter and that the main flue is much too small to handle such a large volume of gas when operating at the maximum rating. In actual practice, however, we doubt whether you could obtain much more than 250 per cent of rating and still maintain acceptable efficiency.

Is Concrete Suitable for Boiler Settings?

WITH REFERENCE to the item "Is Concrete Suitable for Boiler Settings?" on page 761 of the July 15 issue, it may be of interest to call attention to the installation of Vogt boilers at the Schoper plant of the Standard Oil Co., near Carlinville, Ill.

In the plan view of the accompanying figure is shown the construction of the setting walls. The side walls are



PLAN AND ELEVATION OF BOILER SETTING SHOWING EXTERIOR WALLS OF CONCRETE

made of 9 in. of firebrick, 4 in. of insulating brick and on the exterior 9 in. of concrete, with the firebrick bonding into the concrete wall as indicated. In the rear wall the insulation is omitted, there are 9 in. of firebrick and 10 in. of concrete. The concrete was used merely as a covering, as it had given good service for the same purpose at the Wood River Plant of the company. It is not exposed to severe temperature and the hand may be placed on it without any discomfort. The boilers have been in operation for over a year and with the exception of a little surface cracking there are no defects in the concrete boiler walls. The boiler setting is suitably braced and the boiler itself is suspended from steel work as indicated in the drawing.

Louisville, Ky. HENRY VOGT MACHINE CO.

REDUCTION GEARS for the S. S. Malolo, to be furnished by De Laval Steam Turbine Co., will have cast-iron centers with forged steel rims shrunk on and secured by screw pegs. The 25,000-hp., 4-stage turbines will make 1450 r.p.m. and the propeller about 121 r.p.m. Lubrication of the gear teeth will be by means of a series of spray nozzles, delivering at the point where teeth enter engagement.

TO ACKNOWLEDGE and consider suggestions is to foster co-operation.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

Opinions on Business Conditions

At this time of year, attention is turned toward the condition of the agricultural sections. It is the tradition that good crops mean good business years and poor crops, poor years. It is gratifying that the July report of the Department of Agriculture is more optimistic than the report of any preceding month.

Outstanding is the estimate for corn, which may give something over a half billion bushels more than the 1924 production, the acreage of corn this year being estimated as one-half million greater than for 1924.

Cotton is another major crop which shows up well in the July report. South Carolina, Georgia and Louisiana report encouraging crops, having the brightest prospects for 15 yr. All other major crops, especially wheat, potatoes and fruits, carry estimates somewhat below the 1924 production, except barley and tobacco which are estimated to exceed 1924.

While it is an old saying that "one man's guess is as good as another's" we generally prefer to have an "educated guess," which has some foundation on facts and statistics. There are some dozen or more agencies in the country whose business it is to make an estimate of coming business conditions, and an examination of the forecast by nine of these brings out the following points: It is practically unanimous that there will be a good volume of manufacturing production during the last 4 mo. of 1925. Some authorities expect it to hold a steady course at about present volume. Others feel that there should be a healthy increase, but none expect a boom.

Prices for stable finished products may rise slightly, but it is expected that these will stay low enough to encourage buying, particularly of steel by the railroads. There is somewhat of a question as to the effect of a possible coal strike or possible railroad labor troubles but, unless these develop a situation more acute than is anticipated, the opinion is that business will continue steadily at about the same volume as at present.

Exertion, Pfd., Is Today's Best Investment

Railroad stocks are today quoted higher than at any time since 1917. Spite of isolated slumps in some industries, stocks and bonds average at high values. During the present year net deposits in national banks, check transactions, car loadings and new construction all have reached record heights. Commodity prices are steady.

All these are details in a picture of business prosperity. They denote activity, not inaction. They indicate conditions as a whole and it behooves everyone who is not doing reasonably well to ask himself "Why not?" Those few who must ask such a question will probably find the remedy in an investigation of their business.

It may be necessary to develop new methods of distribution or production. Help may come from the addition of new lines or the abolition of old ones which are not paying expenses. For many months textile mills were in difficulties. Now most of the cotton mills are changing their red ink balances to black because of profits made from the new Rayon fabric. Pulverizing slate and incorporating it into rubber goods has helped the mining industry. Makers of phonograph records are discovering that the radio broadcast can be a wonderful selling agent instead of, as was feared, a competitor.

No one should delay starting business activity because "labor costs are high." The price of labor will not soon come down, probably not for many years to come. Recently two large industries have swung over to the 8-hr. day. The steel industry has changed and in the oil industry, which has had a 12-hr. day for time out of mind, men who formerly earned $1 an hour for 12 hr. are now receiving $1.25 an hour for 8 hr. Even these large organizations, which move slowly, have found it no longer profitable to retain the long day. Labor is receiving more today for its efforts than ever before, but to delay business activity in the belief that labor costs will come down will serve only your competitors. Business today is to be had, the times are healthy, but it requires a hard push to achieve success.

Evolution in Industry

Regardless of the final outcome of the controversy in court whether evolution is to be taught as a scientific truth to American school children, the principle of evolution in American industry to develop commercial progress can hardly be questioned. Increasing demand for finished products, constant urge for increased production and need for improved methods have been the factors in the evolution of our industries from their early inception up to the present stage of development. Largely, however, this evolution has gone forward in the last few years. While the personnel of manufacturing plants has doubled since 1900, the production has increased six fold.

As a few examples of this since 1900, the production of pig iron per man has increased from 267 T. up to 702 T. In glass work, production has risen from 55 sq. ft. per hr. per workman to over 3000 sq. ft. Newspapers have increased in circulation per employe over 2500 per cent in the last 25 yr. Gasoline output per employe was 23,000 gal. in 1900, as contrasted with the present day output of 75,000 gal. In our power plants we now have machines which will lift a 70-T. gondola car of coal from the track, turn it topsy-turvy, tumbling out the coal, and set the empty car back on the rails in 60 sec., using only one 35-hp. motor operated by one man. Up in the iron range in Minnesota they are using electric shovels which scoop up 75 T. of ore at a single bite, while in Philadelphia, certain dock equipment, by enabling 12 men to do what formerly required 1100 men, has released over 1000 workers for more productive activity.

Within the memory of most of us have been developed electric motors, sewing machines, babbit metal, automatic couplers, adding machines, telephones, the radio, automobiles, air brakes, pneumatic riveters, the X-ray, linotype machines, vulcanized rubber, hydraulic presses, nickel steel, ether, celluloid, cylinder presses, positive motion looms, player pianos, time clocks, CO_2 recorders, why continue the list? One thing has almost universally escaped us. That is that in manufacturing and in selling, basic principles are the same.

Too many industrial leaders still feel that their problem is different. Too few manufacturers know that they

can learn much of other manufacturers in entirely different fields. In the manufacture of such highly different products as ink, nitroglycerin, salad dressing, sugar, condensed milk and cement, several identical engineering chemical processes are used. As a matter of fact, there is a bond of relationship between all industries.

It would be of great benefit to both industries and individuals if, as often as possible, manufacturers would visit plants outside their field. The paper manufacturer could learn by a trip through a candy factory and the automobile maker would find much to his benefit in studying the processes in a glass factory.

Day dreams often bring inspiration; inspiration gives rise to invention and invention improves methods and processes. Improvement cuts cost and this increases profits and induces greater effort. Larger efforts employ more men, and as a last link in the benefit to humanity, employment and the profits of industry produce schools, institutions, art galleries and all of the by products of prosperity.

Taxation and Income

According to the National Industrial Conference Board, 11½ cents of every dollar of national income is absorbed by taxation. High as that may seem it is less by considerable than in most European countries. The table herewith, adapted from the figures of the Conference Board, shows the national income and annual taxation for four leading European countries and for the United States. The figures are for the year 1924, and converted into United States values at average exchange rates:

	Taxation (National and local) per capita	National income per capita	% of national income absorbed by taxation
Great Britain ...	$88.94	$374.74	23.2%
France	39.07	186.98	20.9%
Italy	19.04	99.17	19.2%
Belgium	24.83	146.06	17.0%
United States...	69.72	606.26	11.5%

While this shows us to be considerably better off than our friends in Europe in the matter of taxation, our position would be materially better, if local and state governments would curb their expenditures and decrease their part of the taxation. Expenditures by states and cities have been growing tremendously during the past few years with resulting jumps in taxes and at the present time nearly 61 per cent of the total taxes in the country are imposed by states and municipalities, while local taxation in the countries tabulated above averages less than 15 per cent. It is time that we take stock of what is happening and insist that our local governments give heed to what they are about.

Increasing Opportunity for Old Virtues

In a recent United Business Service bulletin there appeared an editorial which brings home to us the fact that we are finally getting "back to normalcy." We quote, in part, as follows:

"A noticeable and gratifying feature of the present business movement is what may be called the rehabilitation of the old fashioned business virtues. In the expansive days of the War and post War boom, it seemed at times as if conscientiousness, thrift, economy, carefulness and a sense of obligation were so many obstacles to the larger sort of success. Even such ordinary essentials as experience and understanding of the business seemed to give little advantage. Audacity appeared to seize the prize before it could be awarded to the deserving. Men started all sorts of ventures on a shoestring, plus unlimited nerve, and speedily got rich on other people's money.

"Today, the audacity specialist is at a distinct discount. The nervy 'go-getter' in business, full of pep, dash and daring, does not seem to last very long. He is not able to stand the daily grind. The more conservative man who watches costs closely, follows a cautious policy in financial operations, buys carefully, and is conscientiously careful about the maintenance of quality and having all deliveries fully up to sample, is the one who is keeping a safe distance ahead of the sheriff.

"He is not making extraordinary profits; but neither is anybody else. He will not be numbered among the commercial casualties, however, and as some of his more spectacular competitors pass out of the picture, his position is quietly strengthening.

"If to the old fashioned business virtues a business man can add a spirit of careful progressiveness in devising new methods of marketing and new ways of saving on production costs, then he may be sure that his future, if not spectacular, is at least safe."

Comparative Production Trends

Statistics afford, perhaps not the best, but certainly the most concrete guide to business activity. Below are given the percentages of changes in a few of the more significant factors influencing current trade activity. The first column indicates the change between May and June of 1925. The second column gives the change between June, 1925, and June, 1924.

	% of change from May 31 to June 30, 1925		% of change from June 30, 1924, to June 30, 1925	
U. S. Steel, unfilled orders	Minus	8.3	Plus	13.7
Zinc	Minus	7.6	Plus	5.7
Pig iron	Minus	9.	Plus	31.5
Steel ingots	Minus	7.2	Plus	55.9
Petroleum	Minus	2.6	Plus	11.7
Textiles	Plus	3.4	Plus	70.8
Automotive	Minus	2.	Plus	15.6
Locomotive, shipments	Plus	4.1	Minus	24.1
Sears-Roebuck, sales	Minus	7.8	Plus	15.4
Montgomery-Ward, sales	Plus	19.6	Plus	10.6
Woolworth, sales	Minus	3.1	Plus	15.6
Car loadings, revenue freight	Minus	18.5	Plus	9.1
Construction (36 states)	Plus	8.9	Plus	39.5
Failures	Minus	1.2	Plus	8.5
Liabilities in failures	Minus	8.7	Plus	7.6
Fire losses	Minus	18.9	Plus	16.2

Even casual study of these figures clearly indicates the present status of industry as compared with one year ago. With the single exception of shipments of locomotives and the plus signs before the last three items, every factor shows a healthy gain during the past 12 mo. Many of the gains are considerable and show the post-election expectations of last November to have been fairly well grounded. They also show that business gains are more healthy when they come like interest on money. Three, four or five per cent does not mean a great deal when considered on a monthly basis. But allowed to accumulate over a period of a year, the total proves entirely satisfactory.

EDITORIAL COMMENT

Coal Should Fit the Plant

Every power engineer knows that excessive ash in coal is bad for furnace efficiency, also that excessive sulphur is liable to increase corrosion. But how many know whether or not they are getting the best available coals for their plants? All coal may be coal but all coals are not alike and grates, draft and settings have much to do with what kind of coal is best suited to a plant.

Not always, but generally, the best quality coal is cheapest per 1000 lb. of steam made. To determine what kind of coal will be best for any plant requires analysis of the conditions and requirements at that plant, probably supplemented by some experimenting. When that much has been settled, comes the question, "What is the best source of supply?"

During the war, one had to take anything he could get and burn it as best he might. Before that progress was being made in buying coal on specification and checking it by test. Since the war, most plants have not seriously set about getting the coal best for their use. But it is time the matter be taken in hand.

Service organizations are available which specialize on the problem of what coal is best suited, where it may be obtained and the comparative costs of making steam with coals from various sources. Their help is well worth securing and, with a proper system once established, it is a simple matter to insure that proper coal is bought, delivered and so burned as to give best economy.

Are You Ready?

Once more newspapers are giving front page space to the subject of a threatened coal-miners' strike in the anthracite fields and once more the most vital question confronting power producers must be faced. If a strike materializes, there can be no doubt but that it will be only a question of time before a shortage of coal will result. Have you stopped to consider what measures you have taken to assure continuous operation of your plant?

Strikes in the coal fields have occurred at frequent intervals in the past. American industry and commerce have experienced serious interruptions and great losses as a result of these strikes. Constant rumblings from the coal fields have shown clearly that the whole industry is still on an uneconomic foundation. No one group of individuals associated with the production or distribution of coal is wholly responsible for the present condition and, likewise, not one of them, if standing alone, can bring about a cure. Producers of power all look to the operators and the miners to co-operate and thus insure that the mines remain on a producing basis. Later in the season they will expect the operators and the railroads to co-operate in order that coal may be delivered. In other words, the consumer calmly stands by and expects something from others which he will not give and that thing is co-operation with the other parties involved.

That which has occurred in the past will in all probabilty occur again in the not far distant future. The agreement now being sought by the anthracite miners will be in effect until 1927, when the bituminous coal miners' agreement expires. Is it not reasonable to surmise that there is a double purpose in the present move? Is it only to gain some specific demand, or does it mean that in 1927 both the anthracite and bituminous coal fields will be closed to operations, thus making the situation worse than that existing at present?

In 1923 many coal bins were caught empty. A scramble for what coal was available resulted only in higher prices and, with soaring prices, the coal supply continued to dwindle. These are historical facts, repeated many times within the past few years. Now then, why not get down to your situation? Do you store coal? Are you really making an effort to co-operate? Can you not see that the common interests are also yours and that by promoting them you are promoting your own interests?

Your coal bins have been empty in the past. You are threatened with the same situation today. 1927 is but two years ahead. You are not prepared today. Will you be prepared in 1926 and 1927?

All Dressed Up with No Place to Go

At the present time the newspaper and various technical magazines are filled with information about Muscle Shoals. Announcements that the Wilson Dam will be completed during the latter part of this year, announcements that various large industrial organizations have been asked to buy the power to be generated while the plant is being tested, announcements that the government cannot undertake to supply a stated amount of test power for any definite period and a multitude of other announcements have served to confuse the public mind in regard to this project.

In a recent address, a prominent consulting engineer stated that "the narcotic and hypnotic effect of superlative terms as to Muscle Shoals, used repeatedly, has produced a distorted popular perspective. A public opinion has been created that the military and economic strength of the nation is dependent upon Muscle Shoals." He then pointed out that the government will possess at Wilson Dam a hydro-electric plant with a capacity of 100,000 primary horsepower, costing about $49,000,000, or an investment cost of about $490 a horsepower, whereas a high grade steam plant can produce a horsepower with an investment of $125, including reserve equipment.

Several other factors, which cannot be discussed in detail here, serve to complicate the problem. Production of nitrates for fertilizer derives no abnormal advantage from use of power generated at Wilson Dam. Power from any other source would do just as well. Furthermore, to compare the cost of nitrogen fixation with the final cost of fertilizer made from it is like comparing the cost of raw wool with the cost of a woolen suit made from it."

In the second place, although the contract between the government and the American Cyanamid Co., by which the company was to be allowed first opportunity to buy back the nitrate plants it built at Muscle Shoals, has been declared void, the legal complications it has caused are not yet settled. Finally, in an amendment to the National Defense Act, under which the whole development was undertaken, there appears a clause stating that these plants "shall be constructed and operated solely by the Government and not in conjunction with any other industry or enterprise carried on by private capital." Until that amendment is repealed, the entire plant cannot legally be sold or leased. This point seems to have been generally ignored.

Out of all this confusion, one way seems to be for Congress to repeal the act that it would itself violate by attempting to have the government operate the Muscle Shoals development; to allow the American Cyanamid Co. the first opportunity to purchase the nitrate plants at the government's own terms and, finally, to sell or lease the Wilson Dam plant so that it can be made part of an integrated and interconnected power system serving the market that already exists for its power within easy transmitting distance. Whether or not the plant could be operated in a system controlled partly by the government and partly by private capital is an interesting question.

At all events, as it stands now, the Wilson Dam plant is nearly ready to operate. So far, the only user in position to buy power from the plant during its tests is the Alabama Power Co., although others have been requested to bid for it. Muscle Shoals, in short, is all dressed up with no place to go.

Pigs Is Pigs

Almost everyone has read or at least heard of Ellis Parker Butler's famous classic about the obdurate old express agent who insisted that rules are rules and "pigs is pigs," even to classifying guinea pigs as domestic pigs. The official rules and regulations of the express company were his bible and everything not provided for therein wasn't worthy of notice. He couldn't think past the Book of Rules nor conceive of any circumstances which would cause a rule to be disregarded.

It seems that in our ever-growing industrial enterprises there is an increasing tendency for many to think that "pigs is pigs." Every village or city, state or nation has its rules and laws; from the humblest to the mightiest business, rules must regulate the actions of both employer and employe. No organization could long endure, if there were no rules. But there are times when humanity and justice would be better served, if certain rules were ignored or at least given a liberal interpretation. Form 907-B, made out with punctilious care in quintuplicate, may be all right in a majority of cases but there may come a time when it doesn't fit; when personal judgment must rule, if everyone is to get a square deal.

When E. H. Harriman, the great railroad magnate, was at the height of his career, he is said to have remarked that "any fool could obey a rule but it took a man with brains to know when to disobey." He knew the value of permitting men to think for themselves and, in a large measure, it was this recognition of personal judgment that caused his rise to power in the financial world.

We realize, of course, that advocating personal judgment over general rules is a delicate subject. Opponents of this idea will argue that in every walk of life there are many who might abuse the privilege. They will say that the ordinary worker has no sense of proportion and no ideas of what to do in an emergency. Give him freedom of thought and action and he'd make a mess of things.

Happily, however, experience in most cases has proved that, where men have shown the ability to think for themselves, their natural impulses are constructive rather than destructive and, if given proper supervision, they will develop into valuable assets to the company. Either they have helpful ideas or they haven't any. This may be open to dispute but we have generally found that, if a worker having the least bit of natural ability is given a chance to think for himself and is not tied down by iron-clad rules which must be strictly adhered to on every occasion, he will rise to an emergency and give his employer the best that is in him. If, out of 100 workers who are allowed to think for themselves, only one is found who displays exceptional ability, the employer will still be farther ahead than if he discouraged the development of all of these men.

One day we went into a cafeteria where they had an unusually attractive display of food. We are quite fond of corn and lima beans mixed but they had only separate dishes of each kind of food. They asked the same price for a dish of corn as for the beans, so we asked an attendant whether we could have a dish of half corn and half beans since the portions of each, as ordinarily given, were so large that we didn't feel like eating so much. Not a chance! We were coldly informed that Rule 11,871 specified that no half-portions of any dish were to be sold. We argued that we didn't want half portions of each dish served separately but simply dip out a spoonful of beans and a spoonful of corn from their respective kettles, put them together in a saucer and we would then have the equivalent of one dish of either corn or beans.

"Pigs Is Pigs"—it simply couldn't be done, so the upshot of the matter was we didn't take either corn or beans. The attendant lost the opportunity to be a real salesman rather than a mere dispenser of food and the management almost lost a customer. However, we decided to try our luck with another attendant, so next day we made the same request and, somewhat to our surprise, the man behind the spoon complied with alacrity. He not only gave us what we asked for but actually *sold* us a larger tray full of food than we'd ever gotten in that place before. He was a man to whom the spirit and not the letter of the law was the thing that counted.

Perhaps a manager who was a stickler for exact discipline and a proponent of the theory that "pigs is pigs" might have discharged him but we'll wager that this particular young man will one day be a manager while the stickler for Rule 11,871 is still wielding the spoon.

And what is true for the food dispenser is true for other walks of life, power plant operators included. We are pleased to note, however, that in a majority of plants power plant employes are not hampered by senseless restrictions. Emergencies constantly arise which cannot be foreseen or governed by prearranged rules. The man on duty must think for himself and think quickly. Power plant men should appreciate their privileges and prove worthy of their trust.

KEEP YOUR BOILER room floor clean so that your firemen and watertenders may keep their eyes on the water gage glasses and steam gages without having to give too much attention to their feet.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

New Line of Iron Body Gate Valves

EXCESSIVE wear and marring of the seating surfaces incident to the dragging of the disc upon the seats is eliminated in a new line of iron body gate valves made by The Lunkenheimer Co., Cincinnati, O. This

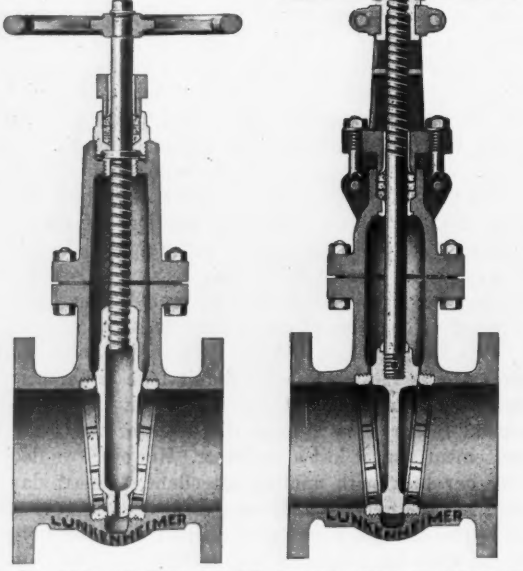


FIG. 1. DISC OF THE INSIDE SCREW TYPE IS HOLLOWED ONLY TO RECEIVE THE STEM

FIG. 2. DEEP STUFFING-BOXES ARE A FEATURE OF THESE VALVES

is effected by the finishing process, whereby the side-play of the disc is controllable and it neither drags on the seats nor touches them until the valve is fully closed. The disc of the inside screw, stationary steam pattern, is hollowed only to the extent sufficient to receive the stem. That of the outside screw and yoke, rising stem pattern, is solid throughout. The advantage of a solid disc is that when expansion and contraction occur, both sides of the disc are simultaneously affected, thereby preventing distortion or fracture and insuring tight seating surfaces. The exceptionally deep stuffing-box provides a large packing surface. The stuffing-box is repackable under pressure when the valves are wide open, a tight seat being formed between the top of the disc and the bottom of the stuffing box bushing.

One of the features of these valves is that of the two lugs provided within the yoke arms directly above the stuffing-box gland. When it is necessary to repack the valve, the gland is raised above the lugs and by slightly turning it, the flange on the gland will rest upon these lugs, thereby dispensing with the usual method of tying up the gland while the stuffing-box is being repacked. Convenience of repacking is also afforded by the use of swing bolts which retain the stuffing-box gland. To raise the gland requires loosening of the nuts sufficiently to permit swinging the bolts aside. Entire removal of the nuts is not necessary. At no point does the stem come in contact with iron, as the yoke, gland and bottom of the stuffing-box are all bronze bushed. The stem, disc faces and seats are also made of bronze. Face to face dimensions of the flange ends valves are what is generally accepted by the trade as "standard."

Recording Water Level Gage

IT IS not necessary to install the new Bristol-Derr water level gage, developed by The Bristol Co., on the boiler front. They may be located even at a distance from the

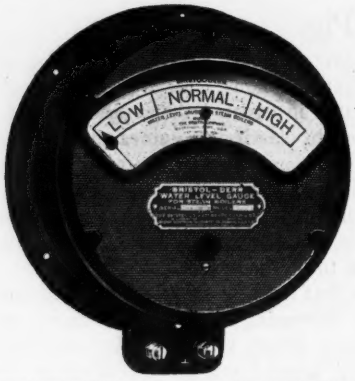


FIG. 1. INDICATORS MAY BE USED IN COMBINATION WITH RECORDERS

boiler at a convenient location where they can be easily referred to. The indicator is primarily intended as an auxiliary to the usual water glass. The recording instrument furnishes a continuous record of every change in the water level in the boiler. A record of this kind is particularly helpful for the chief engineer, as it enables him to check up on boiler room operation; thus any neglect or abnormal condition affecting water level is positively revealed by the chart. In case of damage resulting from high water or low water, the chart record gives evidence.

These instruments are operated by an electric current generated by a series of thermo-couples wound on a metal tube. No batteries or other source of current is required. The metal tube to which the thermo-couples are attached is a standard ½-in. brass or steel pipe, depending on

operating pressure, and is connected to the boiler in the same manner as a water-column. The upper end is connected to the steam space and the lower end to the water space of the boiler. Connections are made through the water-column pipes or fittings, or directly to the boiler drum as desired. There is a protecting case surrounding the thermo-couples and from these a pair of insulated copper wires lead to the indicating or recording instrument.

Installed in this manner, the water inside the tube will stand at the same height as it does in the boiler. Above the water level the pipe is full of steam, which is, of course, at the temperature of the steam. The water in the pipe is in a quiet state, and a great deal cooler than the steam above. Sometimes there is as much as 200 deg. difference. When the water stands high in the boiler this difference in the temperature between the steam and the water in the tube is at a maximum, and when the water is low in the boiler, the whole pipe is full of steam and is uniformly hot. As the water rises and falls, the variation in temperature along the tube produces a varying electrical current and the variations of this current correspond exactly to the changes in water level. These variations in the electrical current are measured by the instrument and indicated or recorded on the instrument in terms of water level.

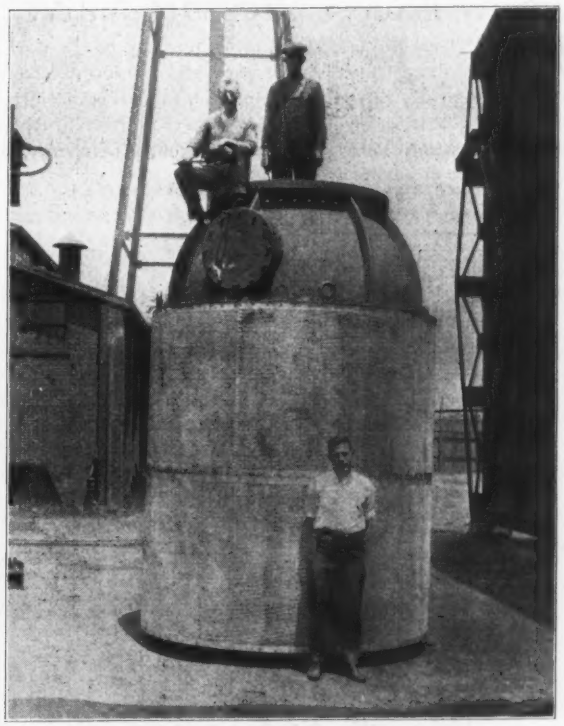
FIG. 2. IRREGULARITIES OF FEED WATER REGULATION ARE SHOWN ON THE CHART

Foaming or priming caused by gradual accumulation of dirt, sludge, or grease in the water is also revealed by the recording chart, the fluctuations in water level becoming more rapid and frequent. The whole appearance of the chart is altered and the change can be detected at a glance.

Foot Valve of Unusual Size

ILLUSTRATED herewith is a continuous service foot valve built by the Newman Manufacturing Co. of New York for a 42-in. suction pipe. The extreme diameter is 7 ft. 7 in., the height is 11 ft. 6 in. and it weighs 12 tons. The capacity of the screens is equal to seven times the capacity of the suction pipe.

This foot valve consists of two cylindrical perforated screens of different diameters, one placed within the other. The smaller one is secured to the foot valve proper and the larger one placed outside or over it and so arranged that it can be hoisted by ropes or chains to the surface of the water for scraping and cleaning without disconnecting either the foot valve or the pipe or stopping the pump. The ring to which the lower edge of outer screen is secured is beveled to a knife edge, so that when lowered into position it scrapes the outer surface of the inner screen of any refuse which may have accumulated while the outer screen was raised. All refuse, such as leaves, fish, sticks, paper and rags that lodge against the outer screen are easily



FOOT VALVE THAT WEIGHS SEVEN TONS

removed therefrom when the large screen has been brought to the surface of the water. The opening of the suction pipe extension is within a few inches of the bottom plate of the screen permitting successful operation at low water.

Westinghouse Co. Builds New Transformer Plant

AT SHARON, PA., a fully equipped plant of large capacity for the carrying on of straight-line production of transformers has been erected by the Westinghouse Electric and Manufacturing Co. This plant cover 42 acres of land and has a floor space of 700,000 sq. ft. The production of distribution transformers, instrument transformers, power transformers, reactors, street-lighting reactors, and rotary transformers will be taken care of in this new plant. The materials used in the production are taken in at one end of the plant and gradually go through long buildings, coming out at the other end as a complete transformer ready for shipment.

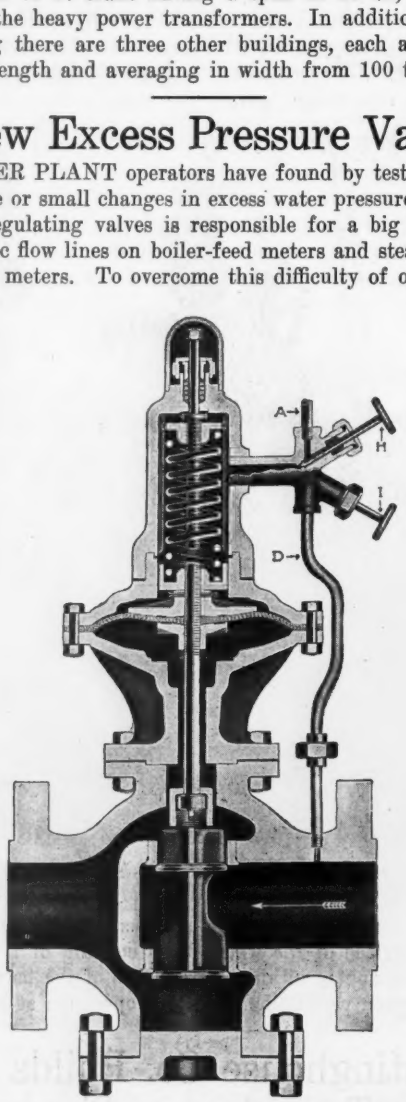
For testing purposes this new Sharon plant will be equipped with the most modern of apparatus. It will include an 800,000-v. unit and a 500,000-v. unit which will

permit the obtaining of any voltage from 1,300,000 v. down.

An outstanding feature in the design of the plant is the immense size of one of the buildings. This building, one of the largest in the world, is 1200 ft. long and 150 ft. wide and 86 ft. in height. Inside this building is installed a 75-T. crane having a span of 85 ft., used for lifting the heavy power transformers. In addition to this building there are three other buildings, each about 1/5 mi. in length and averaging in width from 100 to 200 ft.

New Excess Pressure Valve

POWER PLANT operators have found by test that the large or small changes in excess water pressure at feed-water regulating valves is responsible for a big majority of erratic flow lines on boiler-feed meters and steam-delivery flow meters. To overcome this difficulty of operation,



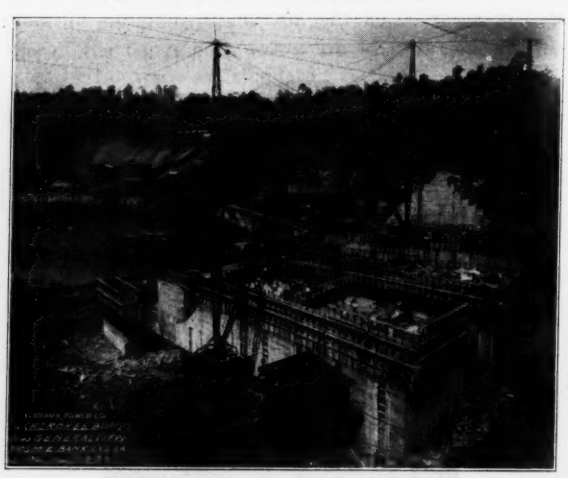
EXCESS PRESSURE VALVE ADAPTABLE TO ELECTRICALLY DRIVEN PUMP AND FEED WATER REGULATION

The S-C Regulator Mfg. Co., Fostoria, O., has developed the type "S" excess pressure valve. This valve can be used either in the discharge of electric driven pumps or ahead of individual feed-water regulators. In each case the steam pressure connection is made at point A. This valve has several advantages in that it has an adjustment available at all times so that it can be set for any excess pressure; furthermore, it is of the tight seating valve type. The valve in question uses a heavy, special rubber and fabric composition diaphragm which will withstand 800 lb. pressure.

Referring to the cut shown herewith, incoming water passes through the valve seats. The pressure past the valve seats is always under the diaphragm, tending to pull the valve shut. The steam pressure or boiler drum pressure is connected to pipe A and exists on top of the diaphragm at all times. If the spring tension is released, then an increase of a small fraction of an ounce pressure under the diaphragm will close the valve. To establish the differential it is necessary only to remove the cap and turn the adjusting screw left-hand until the proper excess pressure is carried over the steam pressure. To bypass the valve, close the needle valve H and open needle valve I. To operate, close needle valve I and open needle valve H.

Cherokee Bluffs Installation Will Total 135,000 Hp.

WATERWHEEL-driven generators to be installed in the new Cherokee Bluffs plant of the Alabama Power Company will total 135,000 hp. There will be three 45,000-hp. (37,500-kv.a.) units, the largest in the southern states. With the exception of those at Niagara Falls, they will be the largest in the United States. All of the generators are being furnished by the General Electric Co. Two



CHEROKEE BLUFFS DAM AND POWER HOUSE UNDER CONSTRUCTION, JULY 2, 1925

of the waterwheels will be supplied by the Allis-Chalmers Manufacturing Co. and the third by the William Cramp and Sons Ship and Engine Building Co.

Generators are rated 37,500 kv.a., 88 per cent power factor, 120 r.p.m., 12,000 v., three-phase, 60-cycle, vertical shaft, with direct-connected exciter, and General Electric spring thrust bearings.

It is expected that the plant, which will be interconnected with the other plants of the company, will be completed during 1926. The water storage plant will provide the greatest artificial lake in the world, with an impounding capacity of 530,000,000,000 gal. of water. It will have a shore line of 700 mi. and will cover 40,000 acres.

So vast a store of water is this that its control at Cherokee Bluffs will practically assure 4-ft. navigation in the Alabama River, into which the Tallapoosa flows, practically the year around, to the Gulf of Mexico. The danger of flood in both the lower stretches of the Tallapoosa and in the Alabama will be reduced to a minimum, thus freeing from the hazard of flood some of the richest farm land in the world.

To construct this project, it has been necessary for the power company to construct a city of 3000 people in a wilderness and to build their own railroad connecting with a distant trunk line. Not the least of the advantages which will be provided by the Cherokee Bluffs plant, will be the opening to transportation of a great area which has hitherto been connected with the railroads by poor roads or has been barren and unproductive by reason of no roads at all. In order to make this reservoir safely navigable, healthful and beautiful, and to minimize the likelihood of the waterwheels becoming clogged by timber and underbrush, the Alabama Power Co. is spending approximately $1,000,000 in making it as clean as a kitchen floor, before the dam is completed and the water impounded. A force of 500 men has been at work for a year at this duty and will be occupied for the next two years before their task is completed. The most approved methods are used and added to those hitherto employed are a number of improvements invented by power company engineers and specifically devised to meet the problems encountered.

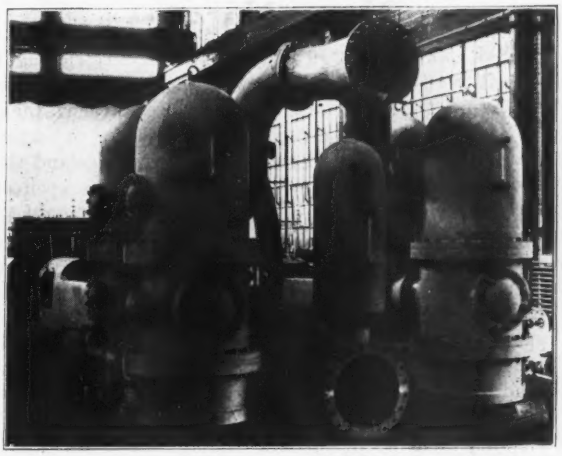


FIG. 2. VALVE DECKS CAST SEPARATE AND VERTICALLY OPERATING VALVES WITHOUT CAGES ARE FEATURES OF THE WATER END

Installation of New Unit at Monroe Pumping Station

IN THE August 15th issue, it was stated that a second pumping unit was to be installed by the Murray Iron Works, but it appears that, since the article was written, the installation of that unit has been finished. Illustrations of the unit, showing the steam end and the water end are accompanying.

Of cross-compound, crank and flywheel type, this engine will handle 5,000,000 gal. a day at 170 ft. head for domestic pressure, but can give 185 ft. head for fire purposes. It uses steam at 150 lb. pressure and turns at 50 r.p.m. Steam cylinders are 18 and 36 by 24 in. and the pump plungers 15 by 24 in. Valves for the water end are mounted on horizontal surfaces, the valve decks being cast separately and no cages used. Motion of the valves is vertical to give the least possible wear on valves and stems.

This unit has been furnished and installed by the Murray Iron Works Co. of Burlington, Iowa.

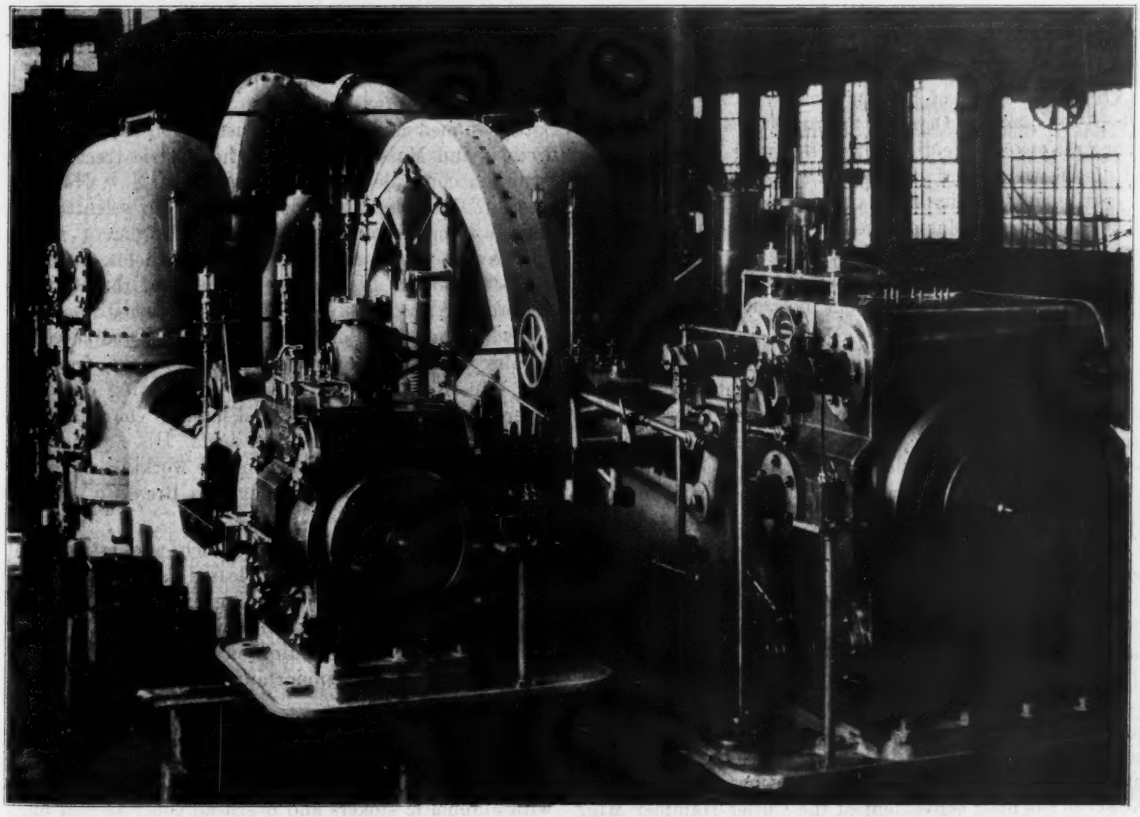


FIG. 1. 5,000,000 GAL. A DAY WILL BE HANDLED BY THIS PUMPING ENGINE AT MONROE, MICH.

News Notes

GREAT LAKES DIVISION of the National Electric Light Assn. will hold a joint meeting with the Indiana Electric Light Assn. at French Lick Springs Hotel, French Lick, Ind., Sept. 23 to 26. Technical papers will be presented on management, operation and commercial topics and the exhibit of the Association of Electragists will be open at the West Baden Springs Hotel. On Thursday night, a banquet will be in order while special arrangements are being made for entertainment of men and ladies during the meeting. Reduced fares have been granted by the Central and Western Passenger Association, special sleepers being arranged from Chicago over the Monon for the nights of Sept. 22 and 23. Round trip certificates can be had from R. I. Parker, General Elec. Co., Chicago; from R. V. Prather, 205 Ill. Mine Workers Bldg., Springfield, Ill.; from J. C. Mellett, Indiana Elec. Lt. Assn., Lafayette, Ind.; from Herbert Silvester, Michigan Elec. Lt. Assn., Ann Arbor, Mich.; from J. N. Cadby, Wisconsin Utilities Assn., Madison, Wis. Hotel reservations should be made direct with the hotel at French Lick, the rates being $10 a day for room and bath for one; $16 a day for two.

NATIONAL SAFETY COUNCIL will hold its fourteenth annual Safety Congress at Cleveland, Ohio, Sept. 28 to Oct. 2. Morning sessions will be devoted to safety precautions in special industries and afternoons to discussions on general safety provision. Of special interest are the meetings on Wednesday morning of the Ice and Refrigeration Section, on Tuesday morning of the Public Utilities Section and of the Electric Railway Section. Some subjects to be discussed are The Best Safety Kink I Have Known, Mechanical Safeguarding, Safety Practices on Construction Operations, Results of Bonus and Award Systems. Further information can be had from A. A. Mowbray, Director of Public Information, 168 No. Michigan Ave., Chicago, Ill.

AT THE MEETING of the American Welding Society to be held in Boston, October 21 to 23, exhibitions and demonstrations of welding processes will be given, including the welding of pipe and all machinery parts and the cutting of pipe in large sizes. These demonstrations will be held at the Massachusetts Institute of Technology from nine in the morning until five in the afternoon and on Wednesday evening at 7:30. Technical papers on welding will be presented at the various meetings of the Society.

UEHLING INSTRUMENT CO., Paterson, N. J., has recently appointed two new southern agents to handle its line of CO_2 recorders and other power plant instruments. John C. Candler, 315 Glenn Bldg., Atlanta, Georgia, will cover Georgia, eastern Tennessee and the southern half of South Carolina and Charles M. Setzer, of Charlotte, N. C., will cover North Carolina and the northern half of South Carolina.

CUTLER-HAMMER MFG. CO., which has always manufactured the Dean valve control apparatus and has recently made other equipment sold by Payne Dean Ltd., such as signal systems, switchboards and load indicators, has purchased the business and patents of Payne Dean Ltd., and will continue the development and manufacture of these devices as well as handling the marketing. Mr. Dean and many of his associates will be connected with the Cutler-Hammer Mfg Co. and will actively assist in the promotion of the work. Future communications should be addressed to the most convenient of the Cutler-Hammer Mfg. Co.'s offices or for the Pacific Coast to H. B. Squires Co. at Los Angeles, San Francisco, Portland or Seattle.

GIRTANNER ENGINEERING CORP. announces the opening of a new district office in St. Louis with manufacturing connections. Louis F. Mahler, 915 Olive St., St. Louis, has been appointed district manager.

FULLER-LEHIGH CO. has closed negotiations with Acers-Poppenhusen Co., McCormick Bldg., Chicago, to act as special sales representatives for the midwestern territory. Principal officers of the Acers-Poppenhusen Co. are Ralph Acers and P. Albert Poppenhusen and chief activity for the present will be in the sale of apparatus for use in connection with pulverized fuel for boilers and industrial furnaces.

GENERAL ELECTRIC CO. paid this month supplementary compensation to its employes at all the factories and offices, amounting to $1,247,496, the distribution being made among 29,558 employes. These payments were made to cover the 6 mo. ended June 30 to employes who have 5 yr. or more of continuous service with the Company, the amount to each individual being 5 per cent of his earnings during the period covered.

DE LAVAL STEAM TURBINE CO. is to furnish the four reduction gears for the turbine-driven steamer Malolo, now under construction by William Cramp & Sons Ship and Engine Building Co. This vessel is of 22,000-T. rating, will have two geared turbines of 12,500 hp. each, and a speed of 21 knots. It will run on the San Francisco-Honolulu route, making the trip in 45 days. The gears are said to be the largest yet built in this country, having a pitch diameter of 140 in. and face of 57 in.

HAROLD BATES has recently joined the sales department of the Bridgeport Brass Co. and will be engaged with matters pertaining particularly to sales organization and research.

After serving in various capacities in the public utility business, mainly with the Boston Elevated Railway, Mr. Bates assumed charge of new construction projects in Connecticut and Massachusetts for the electric traction interests then controlled by the New York, New Haven and Hartford Railroad Co. and, later, made a scientific study of railway operation for the Connecticut Co.

Leaving public utility for industrial fields, he aided in the development of the sales program of the Winchester Repeating Arms Co., during the crucial period immediately following the war. For 5 yr. Mr. Bates served successively as sales engineer in charge of the development of new products, superintendent of the sales engineering department, supervisor of sales planning and later in charge of special and jobbing sales of all new products. His experience will, therefore, be of especial value in the working out of plans to broaden the scope of the Bridgeport Brass Co.'s service to its customers.

DEARBORN CHEMICAL CO., which was established in 1887 and began business in a leased factory at 23rd and La Salle Sts., Chicago, is making extensions to its plant at 1029-37 West 35th St. which will add 10,000 sq. ft. of floor space. The first building on the present location was erected in 1904 and important additions were made in 1921.

In the new building, which is of concrete and brick, power plant equipment will be added consisting of two 72-in. by 18-ft. return tubular boilers, rated at 185-hp., with automatic stokers and overhead concrete coal bunkers

of 150-T. capacity, to be served by a conveyor which will also remove the ashes. A concrete and brick stack, 150 ft. high, will be capable of handling 700 hp., which will provide for further future extensions. A new Corliss engine, 16 by 36 in., will be installed and direct connected to a 150-kw., d.c., 200-v. generator capable of carrying 25 per cent continuous overload. Necessary pumps, open feedwater heater, draft gages, flow meter, CO_2 recorder and all other modern appliances will be provided.

Cost of the plant, which is being built by James L. Fyfe, architect, and Neiler, Rich & Co., engineers, of Chicago, will be $150,000.

RAY PALMER, formerly Commissioner of Gas and Electricity for Chicago and for the past 9 yr. president and general manager of Queens Electric & Power Co., of New York, has resumed consulting practice at 52 Vanderbilt Ave., New York City, on engineering and management of plants.

ARTHUR L. MULLERGREN, Consulting Engineer, Gates Building, Kansas City, Mo., has been retained by the municipal water and light department to prepare plans and specifications for a complete new boiler plant and facilities for the City of Kansas City, Kansas, consisting of the construction of a new building, 3000-hp. capacity in boilers, coal and ash handling equipment, steam piping and boiler room equipment, the estimated cost of which is $700,000.

LOW WATER in the Menominee River has been curtailing power available in the Iron Mountain region so that several power consumers have been obliged to operate on reduced capacity. Some 5000 hp. is being furnished by the coal and oil burning plant at Iron River, but it is not sufficient to meet the deficiency. After the line from Milwaukee to Iron Mountain is completed, about Jan. 1, the Milwaukee plant of the North American Co. will be able to supply power in future emergencies.

SALE OF ITS Oklahoma properties was authorized by the directors of the Missouri Power & Light Co., Mexico, Mo., at their last meeting. It is expected that approximately $4,615,000 will be realized from the sale. The plant at Waurika, Okla., is to be sold to the Southwest Utility Co., and the properties at Durant and Ardmore to the Oklahoma Gas and Electric Co. The Missouri Power & Light Co. is one of the Studebaker group of public utilities, of which the Illinois Power and Light Corp., Iowa Power & Light Co. and Kansas Public Service Co. are others.

W. C. HAMILTON & SONS, Miquon, Pa., makers of paper, who have four steam-driven machines now in use, have decided to electrify the entire plant. Accordingly there will be installed, probably by this fall, a 1500-kw., non-condensing, turbine-driven generator unit which will supply power to four motor-driven mills. The non-condensing type of turbine was selected inasmuch as the mill utilizes a large quantity of process steam.

All the electrical equipment will be of General Electric manufacture, power being distributed throughout the mill at 480 v. The paper machines will be operated by the single-motor type of electric drive, using four 80-hp. adjustable-speed motors, taking direct current from four 75-kw. motor-generators, one located at each machine.

The jordans have been belt driven from the same system of line shafts which drives the paper machines. When the new installation is completed, each jordan will be driven by an individual 150-hp., direct-connected, synchronous motor. A number of 10-hp., induction motors will also be installed for general duty about the mill.

RAYON, commonly called artificial silk, more properly called chemical silk, will be displayed at the chemical exhibition to be held at the Grand Central Palace, New York, September 28 to October 3. All phases of manufacture, such as weaving, finishing and dyeing, will be shown. Development in this material has been spectacular. It started with a few thousand pounds production in Europe and now runs to millions of pounds each year in the United States alone. There are now 12 factories in operation and three or four large new plants under construction.

PLANS ARE under way for a $1,000,000 water power development at White Rapids on the Menominee River. This is about 40 mi. north of Menominee, Michigan, at Ambre, and is estimated to deliver 16,000 hp. to be transmitted to the Northern Paper Mills at Green Bay, Wis.

The transmission line, which is now being constructed, will be jointly occupied by the wires for the Northern Paper Mills circuit on one side of the towers and by the wires of the North American Co. on the other side. About 8000 hp. will be developed at first, according to Judson G. Rosebush, Treasurer of the Northern Paper Mills, and the balance will be developed as the needs of the mills increase.

THE COMMITTEE appointed by Secretary Hoover to consider questions of policy and reorganization in connection with the transfer of the Bureau of Mines from the Department of the Interior to the Department of Commerce will consist of the following: J. V. W. Reynders, President, American Institute of Mining and Metallurgical Engineers, New York, Chairman; C. P. White, Chief of the Coal Division of the Bureau of Foreign and Domestic Commerce, Department of Commerce, Washington, Secretary; H. Foster Bain, ex-Director of the Bureau, New York; J. G. Bradley, ex-President, National Coal Association, Dundon, West Virginia; L. S. Cates, President, the American Mining Congress, Salt Lake City; D. M. Folsom, Vice President, American Petroleum Institute, San Francisco; Philip Murray, Vice President, United Mine Workers of America, Pittsburgh.

CONTROLLING INTEREST in the Western Public Service Co., a Colorado corporation operating in a number of cities and towns in Wyoming, Colorado, Nebraska, Missouri, and Texas, was recently purchased by the Eastern Texas Electric Co. of Delaware, which is under the executive management of Stone & Webster, Inc., Boston, Mass.

The Texas properties are now connected by transmission lines with the Eastern Texas Electric Co. at Sour Lake and serve 25 towns in the vicinity of Beaumont, Texas. The properties in the other states include Laramie, Wyoming; Las Animas, Colorado; Scottsbluffs and Holdrege, Nebraska, and Tarkio and Mound City, Mo. The service is about 60 per cent electric light and power, 32 per cent and 8 per cent steam heat and water. The total estimated population served is 125,000 and the combined earnings for the year ending May 31, 1925, were $1,798,000. The Eastern Texas Electric Co., through its subsidiaries, now operates in Beaumont and Port Arthur, Texas; Lake Charles and Jennings, La., and the territory adjoining these communities. It also holds a contract to purchase the Orange, Texas, property in the near future.

APPLICATIONS will be received by the U. S. Civil Service Commission for the following positions:

Second class Steam Electric Engineman to fill vacancies in the departmental service, Washington, D. C., and in the Indian Service throughout the U. S. Entrance salary is $1320 a year and advancement may be made up to $1680 a year for the Washington positions. For the Indian Service, salary ranges from $1140 to $1320 a year with quarters, heat and light and advancement up to $1500. Requirements are an intimate knowledge of construction and handling of boilers, engines, turbines, condensers, pumps and power plant auxiliaries, of motors and generators, a.c. and d.c., electrical auxiliaries and distribution systems. Applicants will not be required to report for examination but will be rated on physical ability, training and experience.

Under Laboratory Mechanic to fill vacancy in the National Museum, Washington, D. C., and other similar vacancies. Entrance salary is $1140 a year with advancement up to $1500. Duties are to assist in the installation of exhibit material, construction of models and preparation of exhibit material from specifications. Rating will be on education, training and experience without requirement to report at any place for examination.

Full information and application blanks may be obtained from the U. S. Civil Service Commission, Washington, D. C., or the secretary of the board of U. S. civil service examiners in any city. Receipt of applications for Engineman will close on Sept. 21 and for Mechanic on Sept. 22.

Catalog Notes

THAT WORTHINGTON products have been among the leaders in such lines as pumps, condensing equipment, feed heaters, air compressors, meters and Diesel engines since 1845 is the argument presented in a bulletin recently sent out by the Worthington Pump and Machinery Corp. of New York City.

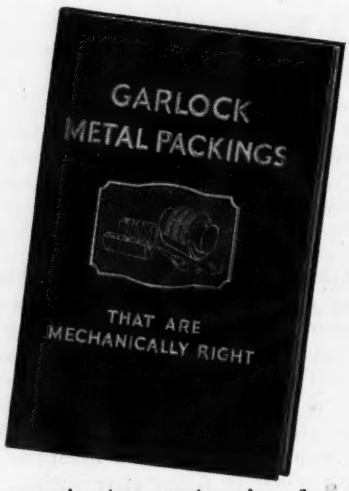
HOW BADENHAUSEN BUILDS BOILERS is the title of an interesting and attractive booklet just received from the Badenhausen Corp., 900 Victory Bldg., Philadelphia, Pa. It gives the principal features of the boiler and shows by a series of shop views just how the work of manufacture is carried on. A copy can be secured by writing to the Badenhausen Corp.

HONECO AIR OPERATED CONTROLLERS for automatic control of pressure, temperature, humidity, liquid levels, dampers and timing are described and illustrated in detail in Catalog No. 2500 issued by the American Schaeffer & Budenberg Corp. Besides showing the construction and operation of the apparatus, the catalog gives numerous blueprint installation diagrams and dimension tables showing methods of use and space required. A copy of the catalog will be sent to those interested on receipt of request.

IN THE NEW Walworth General Catalog, No. 83, is to be found a mine of information on piping and pipe fittings, valves, piping tools, steam accessories and heating and ventilating apparatus. It is a book of over 700 pages in substantial cloth binding, evidently prepared with great care both as to the requirements of the user and the details of book making. Sepia paper and a brown ink have been used to make reading easier; each section has a summary of Walworth practice in regard to the products shown; new lines of steel fittings and valves for high steam pressures are included as well as new lines for high water pressures and fittings and valves for oil and gasoline systems. One section is given to data used by the pipe and fitting trade, another to a telegraph code for quick ordering of any material listed. The book is a complete listing of material for piping systems and should be of great value to designers and executives who can obtain copies by writing to the Walworth Mfg. Co., Boston, Mass.

DRAFT GAGES of various types and designs, which are manufactured by the Defender Automatic Regulator Co., of St. Louis, Mo., are described in Bulletin No. 25, just issued by that company.

ILLUSTRATED herewith is the attractive cover of a new catalog, AA-1925, of the Garlock Packing Co., of Palmyra, N. Y. The inside pages are as fine in appearance as the cover. The catalog describes Garlock Metal Packing service



for rods in ammonia, steam, water, air and gas machinery and gives hints for the application of metal packings. A copy will be sent if you ask for it.

NORDBERG DIESEL ENGINES are described in full detail in Bulletin No. 38 issued by the Nordberg Mfg. Co. of Milwaukee Wis. Features of the type VH are fully illustrated and details of construction clearly shown. A copy can be had on request.

VACUUM RECORDERS are described in Bulletin No. 140, recently issued by the Uehling Instrument Co., Paterson, N. J. These instruments operate on the mercury column principle for which permanent accuracy is claimed. The high degree of legibility of this vacuum recorder is due to the fact that the condenser's working range of vacuum is recorded over nearly the full face of the chart, while the lower degrees of vacuum, down to atmospheric pressure, are recorded on a greatly contracted scale.

NEW DEAD-FRONT fire-pump controllers for squirrel cage and wound rotor motors which have been approved by the National Board of Fire Underwriters are described in a bulletin known as L-1500 recently issued by the Westinghouse Electric and Manufacturing Co. The bulletin gives a general description of the controller and the advantages of a control panel entirely free from all current carrying parts. A detailed description gives the ratings for both the squirrel-cage and wound-rotor types, the arrangement of the operating handles, arrangement of panels and meters, and a description of the cabinet.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

The Water that Will Go Over the Wheel

Approaching the three-quarter post of the year, business of all kinds is prepared to round into the home stretch with a volume, stability and profitableness that has never been excelled in the history of this country.

Authorities in finance, agriculture, merchandising, transportation and industry have facts and figures on conditions as they now are that make the above seem to be a sound and conservative forecast.

In the power plant field the great activity in construction and improvements that has marked the year up to the present point, presages an even more rapid extension of the industry for the balance of the year and for 1926.

Power, directly or indirectly the basis of practically every human activity in this country, is not limited in its generation by growth of population, business or industries.

Yearly a greater proportion of power is used in every product and in every home, for while all grow by power, the profits power earns for them and the conveniences it brings call for its greater use per unit of production and population.

Couple these generally recognized facts with the well-nigh marvelous advances that are constantly being made in the art and science of power generation, familiar only to power plant men, and we have a combination of factors that are building our industry to heights of substantial expansion that is hard to equal anywhere.

To all men this swiftly moving present and ever widening future of the power plant field calls for the best that is in them.

Only constant alertness to the whole vast range of improvements in methods, machinery, equipment and supplies, will enable any man to keep his plant in line with progress.

In a country of great resources and in the era of their rapid development, only the men, businesses, power plants and industries that are ready can seize the opportunities that are constantly arising.

"Water," the old saying goes, "that has gone over the dam, grinds no grist." There is a tremendous head of water, now building up potential power to grind the grist of all our hundred odd millions of people.

In modern terms this old adage means that freight loadings, now approaching the highest in history, are profitable only to the railroads that have cars to load. Power demands will bring no revenue to the companies that sell power, except to the extent that their plants can generate it. Banks will profit by loans to handle the great financial requirements of fall business only so far as they have built up deposits and credits. Merchants will sell only what they have on their shelves.

The day has passed, both literally and figuratively, when demand will wait on the supply. These are the times when human nature has learned to get what it wants and get it quickly.

In every line of business the leaders are studying the future and planning and building today for the growth of tomorrow, next year and even for the next decade.

Nowhere is this combination of great vision, careful calculation and far-seeing action better exemplified than in our own industry, and nowhere has there been such a record of justification in financial support, public approval and solid progress.

Scattered by the wayside are the remnants of former gigantic enterprises that failed and were replaced by others or that are still struggling toward a substantial footing.

Over expansion was often given as the reason for the downfall of those so-called trusts of 10 or 20 years ago. In the light of present-day business methods, it is now evident that it was under expansion of service, of the facilities that make for economy and of care and attention that make for good will that caused these failures.

Is your power plant under expanded?

Competition is close, but it is competition in quality, not alone in size.

Small plants are successfully competing with large ones, engineers and other executives in charge of medium size plants and enterprises are often receiving as large incomes as many better-known, higher-titled men in great corporations.

But don't forget that they earn what they get and that the great corporations are also ever searching for men to whom they can pay even more rewards.

It's a fair fight and no favors with big stakes for the men, plants, machinery and equipment that can show even a little above the average record of results.

Power Plant Engineering is the common meeting ground of all these factors in power generation.

Its own success depends on how faithfully and how efficiently it serves the men who are progressing; its leadership on the extent to which it helps men to better leadership; its growth on the measure in which it helps others to grow.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR CHAMBERS.
Hercules Float Wks., Springfield, Mass.

AIR COMPRESSORS.
Allen & Billmyre Co., Inc., The, New York.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Well Works, Aurora, Ill.
Dean Bros. Co., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Murray Iron Works Co., Burlington, Iowa.
Worthington Pump & Machinery Corp., New York, N. Y.
Yeomans Bros., Co., Chicago.

AIR FILTERS.
Allen & Billmyre Co., Inc., The, New York.
Spray Engineering Co., Boston.

AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Forge Co., Buffalo.
Cooling Tower Co., Inc., The, New York.
Spray Engineering Co., Boston.

ALARMS, HIGH AND LOW WATER.
Hills-McCanna Co., Chicago, Ill.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland, Ohio.
Wright-Austin Co., Detroit.

ARCHES, BOILER COMBUSTION.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Brady Conveyors Corp., Chicago.
Detrick Co., M. H., Chicago.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hofft Co., The M. A., Indianapolis, Ind.
Lavino & Co., E. J., Philadelphia.
Liptak Fire Brick Arch Co., Mexico, Mo.
McLeod & Henry Co., Troy, N. Y.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.

ASH AND COAL BINS.
Frederick Iron & Steel Co., Frederick, Md.

ASH BIN GATES AND DOORS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
United Conveyor Corp., Chicago.

ASH HANDLING SYSTEMS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Hagan Co., George J., Pittsburgh.
Link-Belt Co., Chicago, Ill.
Stephens-Adamson Mfg. Co., Aurora, Ill.
United Conveyor Corp., Chicago.
Webster Mfg. Co., The, Chicago.

ASH TANKS.
Conveyors Corp. of America, Chicago.
United Conveyor Corp., Chicago.

BABBITT METAL.
Magnolia Metal Co., New York.

BAROMETERS.
Taylor Instrument Co's., Rochester, N. Y.

BEARING METAL.
Magnolia Metal Co., New York.
Strong, Carlisle & Hammond Co., The, Cleveland, Ohio.

BELT CONVEYORS.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

BELT DRESSING.
Cling-Surface Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELT LACING.
Bristol Co., The, Waterbury.

BELTING.
Quaker City Rubber Co., Phila.
United States Rubber Co., New York, N. Y.
Voorhees Rubber Mfg. Co., Jersey City, N. J.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN AND FURNACE.
Buffalo Forge Co., Buffalo.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engineering Corp., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Terry Steam Turbine Co., The, Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, PORTABLE.
Allen & Billmyre Co., Inc., The, New York.
Buffalo Forge Co., Buffalo.
Clements Mfg. Co., Chicago, Ill.

BLOWERS, STEAM.
Schutte & Koerting Co., Phila.

BLOWERS, TUBE.
Bayer Co., The, St. Louis, Mo.
Diamond Power Specialty Corp., Detroit.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Webster, Howard J., Philadelphia, Pa.

BLOWERS, TURBINE.
Allen & Billmyre Co., Inc., The, New York.
Carling Turbine Blower Co., Worcester, Mass.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Betson Plastic Fire Brick Co., Rome, N. Y.
Johns-Manville, Inc., New York.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Spec. Co., New York.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER COMPOUNDS.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N. Y.
Paige & Jones Chem. Co., New York.

BOILER COMPOUND FEEDERS.
Hills-McCanna Co., Chicago, Ill.

BOILER FEEDWATER PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chem. Co., New York.
Permutit Co., The, New York.
Power Plant Specialty Co., Chicago, Ill.

BOILER FRONTS.
McLeod & Henry Co., Troy, N. Y.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Lavino & Co., E. J., Philadelphia.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.

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BOILER SETTINGS.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Lavino & Co., E. J., Philadelphia.
McLeod & Henry Co., Troy, N. Y.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.
Webster, Howard J., Philadelphia, Pa.

BOILER SKIMMERS.
Sims Co., The, Erie, Pa.

BOILER TUBE CLEANERS.
Condenser Cleaner Mfg. Co., Pittsburgh.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The Hartford, Conn.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Murray Iron Works Co., Burlington, Iowa.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.
Johns-Manville, Inc., New York.

BOILERS.
Babcock & Wilcox Co., New York.
Badenhausen Corp., Philadelphia, Pa.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Bigelow Co., The, New Haven.
Casey-Hedges Co., The, Chattanooga, Tenn.
Connelly Boiler Co., The, D., Cleveland, Ohio.
Edge Moor Iron Co., Edge Moor, Del.
Erie City Iron Works, Erie, Pa.
Freeman Mfg. Co., Racine, Wis.
Heine Boiler Co., St. Louis.
Kingsford - Fdry. & Mach. Co., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Union Iron Works, Erie, Pa.
Webster, Howard J., Philadelphia, Pa.
Wickes Boiler Co., The, Saginaw, Mich.

BOOKS AND SCHOOLS.
Audel & Co., Theo., New York.
Sweet's Catalog Service, Inc., New York.

BREECHINGS.
Littleford Bros., Cincinnati.

BRICKS, FURNACE LINING.
Norton Co., Worcester, Mass.

BRUSHES, DYNAMO & MOTOR.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Link-Belt Co., Chicago, Ill.
Webster Mfg. Co., The, Chicago.

CARRIERS, PIVOTED BUCKET.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Fuller-Lehigh Co., Fullerton, Pa.
Hills-McCanna Co., Chicago, Ill.
Neemes Fdry, Inc., Troy, N. Y.

CEMENT, FURNACE.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.

CEMENT GUNS.
Cement-Gun Co., Inc., The, Allentown, Pa.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Lavino & Co., E. J., Philadelphia.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Plibrico Jointless Firebrick Co., Chicago, Ill.
Quigley Furnace Spec. Co., New York.

CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.

CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

CHIMNEYS.
American Chimney Corp., New York, N. Y.
Bigelow Co., The, New Haven.

CLEANERS, BOILER TUBE.
General Specialty Co., The, Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh, Pa.
Pierce Co., The, Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.

CLEANING COMPOUNDS.
Dearborn Chemical Co., Chicago.

COAL AND ASH HANDLING MACHINERY.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.